Rock Products

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Foreword

THIS is an unusual issue of "Rock Products"; it is less a copy of a magazine than a quarry hand book or manual. The more the reader will examine it, I feel sure, the more he will appreciate its value to his own business; and he will keep it at his elbow for ready reference.

When it was decided to get up a comprehensive program—last summer—it was realized that if the program was to be worth while, the literature it would produce should become a matter of permanent record and value to the industry. Indeed, we should not have been justified in asking papers from so many notable men, if their remarks were to be lost as soon as they had been uttered.

So it is the function of this issue of "Rock Products" to preserve the transactions of the National Crushed Stone Association, in the 1923 convention assembled; and to go further in the matter of their presentation to the industry than is ordinarily done in the publishing of professional and trade association transactions or proceedings.

Convinced that the information and data herein contained are of very live and practical value to the entire quarry industry, the transactions have been carefully indexed by subject and by author, so that the fullest possible use may be made of them for helping in the solution of every-day problems of operation and management.

In presenting this issue to the rock products industry the editor feels that it is both his duty and a pleasure to extend the thanks of the industry to the many distinguished men who had a part in the program and to all the members of the convention for their hearty co-operation, interest, encouragement and support.

Nathan C. Rockwood

Chairman, Program Committee.

Official Transactions of the National Crushed Stone Association

In Convention at the Hotel La Salle,
Chicago, on January 15, 16 and 17, 1923

Address of Welcome

By John Erickson
Engineer, Commission of Public Works, Chicago

MR. PRESIDENT and gentlemen of the National Crushed Stone Association: I am here today to represent the mayor of Chicago in welcoming you to the city. The mayor would be very pleased to be here personally, but when you consider that there are thousands of conventions and other public meetings in this city every year, if he should appear personally at all those occasions there wouldn't be any time left for him to do any other work.

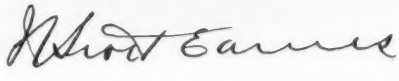
It is a very easy matter to just wish you welcome, but I know when Mayor Thompson appears before gatherings of this kind, he always has a few more pleasant words or something of interest to say besides that.

Now, I don't know exactly what I may be able to tell you or say that will be fitting at this occasion, but during the comparatively short life that I have spent in this city, I have seen the population increase from a little over 500,000 until it is now 4,000,000 or more, and, of course, I have seen everything else that goes with such an increase in population.

We need great quantities of your product in this city. During the year 1922 there were 98 miles of streets paved. If we figure about 16,000 sq. yd. to the mile and a thickness of base on an average of, say, 7 in., you can see for yourself that that alone required a good deal of your product. In addition, we have innumerable other structures; we build bridges and even in our buildings—during 1922 the value of buildings for which permits were issued amounted to—I don't remember exactly, but I know it is considerably more than $100,000,000, and I understand that already this year there have been three times as many permits issued as during the corresponding period in 1922.

Further, we have under construction and under consideration great improvements like the railway terminals, the lake front improvement, the Union Station, which in construction alone will cost in the neighborhood of $100,000,000 before we get through, and then we have the Illinois Central electrification. So you see there is a great demand for your product in this city.

I am glad that there is an organization such as yours because by getting together and exchanging experiences and views, it is natural that you should be able to more efficiently carry on your work and make it possible for this great city, as well as others, to obtain the product when we need it and in the quantities that we need it. The only thing we will ask is that you do not throw it at us, because we have some experiences with that right at home and I can't say that we exactly like it.



Now, gentlemen, on behalf of the city of Chicago and the mayor of Chicago, I wish to bid you all welcome to this city and I hope that you will enjoy yourselves while you are here, although, at this season of the year, perhaps, the city is not quite as attractive as during the summer and the fall, but you can hold two conventions a year and hold one here in the summer also.

President Eames' Address

FELLOW ASSOCIATES, ladies and gentlemen: On behalf of the members of the National Crushed Stone Association, its officers, and friends, assembled here to participate in this convention, I wish to thank Mr. John Erickson, consulting engineer, Commission of Public Works, of this city, for the kind and hearty welcome extended to this association, and, further, to express to him our sincere and grateful appreciation of the courtesy and goodwill shown us by official Chicago.

Since our last annual gathering, not a few matters of national import, directly affecting the business equilibrium of our country, have arisen. Questions pertaining to immigration, better railway transportation, and the growth of the socialistic idea and its resultant unrest, I feel, should be of the utmost interest and extreme importance to this body at this time. I make particular mention on these matters because of their apparent direct bearing upon the crushed stone business of the country.

Features for Consideration

However, before speaking further on these matters I think some features of our present organization should receive consideration. There is no doubt in my mind that this association is a good thing for the purposes for which it was brought into existence, but I wish to ask:

"Are the members satisfied with it as constituted at present?

"Should its membership be increased by reducing the fees to an annual stated amount in place of the present assessment?

"Are the members receiving all that they should from this association?

"Does our organization function properly so as to bring all the benefits its members feel they are entitled to?"

An instance of the benefits to be received through organization can be cited and pertains to a visit to Washington last summer by some of your officers who sought modification of the priority orders issued against the stone producers of the country by the Interstate Commerce Commission.

I feel that, had the stone producers been without organization, they would not have been received with as much courtesy by Secretary Hoover, Mr. Roth and Commissioner Aitchison, as was apparent to those officers who made the Washington trip, and who succeeded in receiving some relief on the car situation. There is no doubt, I believe, in the minds of any members that the membership of this association should be increased.

The Immigration Question

Probably the greatest problem today confronting the employers of labor concerns the immigration question. No doubt you know that the quota from Denmark, Sweden, Belgium, France, and Germany has not been able to come into this country on account of the financial situation of their respective countries. As a result, the labor situation here is very serious. The question arises: Should our organization at this time take up the matter in an attempt to obtain some relief from the present immigration law muddle? Should the bars be lowered sufficiently to allow certain desirable laborers to come into our country to take care of its tremendous growth?

Frankly, I think, in order to learn just how serious our present labor situation is, we should immediately appoint a committee to meet with the American Road Builders' Association while both organizations are holding their conventions in Chicago. They should determine whether some joint action should not be taken at this time in this respect. I think that the appointment of this committee should not be delayed later than today's session.

The Railroad Situation

While I was in Washington last summer Mr. Hoover very frankly told me that the railroad situation was very critical. Recently the Interstate Commerce Commission reported that 9.9 per cent of all the cars on all lines throughout the country are out of order.

The president of the Baldwin Locomotive Works at Syracuse, N. Y., recently stated that the locomotives of the railroads were in very bad condition, and because of this the transportation of this country was far behind. His criticism was that politicians who are in power at Washington at the present time will not relieve the situation as they should. Thousands of loaded cars at Pittsburgh and other large centers were not able to move on account of locomotives that were out of commission. A requisition for more than 140,000 cars had been denied here only a few days ago. What is going to happen to our railroads?

What does this situation mean to our industry?

Are the railroads going to merge into one big system, or will different sections be forced to consolidate, or will the railroads go under government control, which will mean government ownership?

In my estimation, government ownership would be disastrous to our industry, as we would lose the personal, individual touch we now have with our local railroad representatives. It behooves all business men to give this railroad situation a great deal of thought. I feel that a railroad committee should be appointed at once to handle this matter, and, if possible, to work in conjunction with the Immigration Committee for the greatest good of this association.

Throughout the various parts of this great country of ours socialism and its accompanying unrest is now prevalent. No doubt this situation has been brought about by events that probably should be avoided, but at the present time the "water is over the dam."

Our industry represents a capital of more than $225,000,000, and our production may well be termed enormous. Such an organization as this, with its powerful influence, could be made, and I believe ought to be made, a potent factor to better present social conditions. In attempting to rid our country of this socialistic evil we should all bind ourselves to use the same hard common sense that our forefathers used before us.

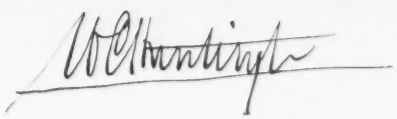
I wish to welcome you all to this annual convention. I am very grateful to Mr. Rockwood and all others who worked so hard to make this meeting a success by planning such a splendid program. I take this opportunity to congratulate him and his committee for all that they have done.

Quarrying as a Business

By William Chapin Huntington

Of Welborn and Huntington, Business Engineers and Counselors, Chicago

I AM not here to talk to you about the technical side of your highly specialized industry; on the contrary, I expect to listen with you to a discussion of this by the able and competent experts who fill your program. My job is to speak to you about quarrying as a Business; to view the business as a whole, for it is a business, sharing with all other businesses the same fundamental problems of price, marketing the product, freight rates, competition, labor, production, costs, and keeping plenty of cash on hand.



Since his graduation from Columbia University in 1907 as a mechanical engineer, Mr. Huntington has entered upon a career replete with rare and valuable experiences and performances. He has been a metallurgical engineer of the National Tube Co., a metallurgist of the Illinois Steel Co.; investigated European industries; managed the Chicago office of the U. S. Bureau of Foreign and Domestic Commerce; was commercial attache of our embassies in Russia and in Paris, and has made an economic survey of occupied Germany for General Allen to show the effect of the elevation of a customs barrier between the occupied territory and unoccupied Germany. Mr. Huntington is also a graduate doctor of engineering of the Royal Technical College of Aachen, Germany, and has labored in German and Belgian steel plants, and made a survey of Russia for openings for American capital and goods.

Complexity of Modern Business

Modern business has grown to be tremendously complex. A business executive today has to deal with a hundred questions in a day, where his grandfather dealt with ten. The tendency is toward larger units, groupings, and certainly toward co-operation as opposed to ruinous unhealthful competition. Under these conditions there is only one way to be successful, and that is, to know all the facts.

The American business man has excellent judgment when he has the facts. I find that business men are inclined to be gun-shy of so-called expert opinions. Give them the essential facts, properly coordinated, and they will form their own opinions as to business situations and policy.

A quarry executive may know all the facts about his own individual business, but does he always know the facts about the industry as a whole? Does he *know* that there is a market for his product; what the normal demand is for crushed stone in the market he can reach; how best to distribute; what new fields are possible; whether the market is expanding or contracting; whether there is over-production under normal circumstances? Does he know what his competitors are doing and thinking? A knowledge of their experience would often show him what

to do and what to avoid doing. Is any related product replacing crushed stone? Will a well-directed selling and advertising campaign check this? What is the effect of engineering standards, specifications, and building legislation on the use of this product?

A man already in business has to know these things to meet competition. They are all the more vital to a concern contemplating opening a new quarry or expanding existing operations.

How to Meet Competition

To get this information you have to make a comprehensive, thorough-going survey of your industry. Such a survey embodies the essential facts about the production and marketing of your product and assembles the experience and the opinions of other producers, of distributors. of men in related lines of business and of consumers.

I know of a man operating a big gravel dredge on the Ohio river who was so convinced of this that he drew out a couple of thousand dollars, left a manager on the job and went all over the United States to learn how other people ran their gravel dredges. However, most business executives are too tied down by manifold and pressing duties to absent themselves thus from their business, and this fact has given rise to the profession of the business engineer and counselor.

A thorough business survey helps to take the hazard out of any business. It saves the executive many sleepless nights and worries, because it shows him just where he stands and what the dangers are. But this is not all. Modern business is largely conducted on credit. Few of us can expand our businesses as we should like out of the earnings alone. We have to have recourse to the banker. A quarry executive with a business survey in his hand is in the best possible position to talk to his banker. The head of a prominent banking institution said to a young manager a few days ago:

"You are an enthusiast about your business and we like to see that, but you can't expect us to take your statements at their face value as we would an unprejudiced survey with the facts in and the personalities cut out."

Another banker recently declared to a large manufacturer:

"If you will bring me a favorable business survey of your enterprise, you can have all the direct and indirect credit you need for 6 per cent without commission. Without such a survey, I confess we don't know enough about the hazards of your business to make a loan."

It is of interest that the previous loan obtained by this same manufacturer cost him about 15 per cent, including commissions.

Investment bankers, as is well known, are glad to be approached by sound, well-managed industrial enterprises. One such man said to me the other day:

"I would rather put a bond issue on a company with a well-surveyed future than on some I know with a better-advertised past."

Business conditions today are forcing producers to abandon the attitude of unhealthful cut-throat competition and to co-operate in the largest possible measure. There is a tremendous mass of business information and experience which can be exchanged among producers in an industry such as yours, without detriment to anyone and with benefit to all.

That is why you have come together in this convention. It is the reason for the great services which are being rendered today by well-managed trade associations and it explains the growing demand for co-operative surveys made for all the producers in an industry or one special group of them.

Basic Facts Are Business Stabilizers

This putting the basic facts about their industry into the hands of all the producers is a wonderful stabilizer, the best possible check on ignorant price cutting, and puts the competition on a high ethical plane. And if you don't believe that ethics has a very immediate and practical bearing on your industry, let me assure you that the attitude and conduct of producers in an industry toward one another have a great deal to do with the merchantability of the securities of any one of them.

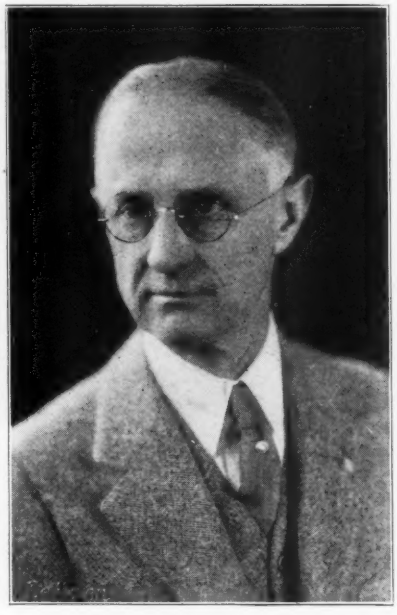
Gentlemen, I do not doubt that in what I have said I have but given expression to thoughts which have been running in the minds of many of you. You have a big industry with a splendid future within your grasp, a future in which all decisions and policies shall be based, not upon individual experience alone—and certainly not upon rumor and hearsay—but upon a thorough fore-knowledge of the facts.

Transportation Situation Reviewed

By E. J. Krause

Vice-President and General Manager, Columbia Quarry Co., St. Louis

IT is up to each of us to take the UN off of uncertainty. The world is full of UN-certainty at the present time. The press is full of it—the public absorbs it like a blotter absorbs other carelessly handled ink. The happenings, politically, of the nations of the world, including our own country, breed uncertainty—yet this is misapplied psychology. It is ludicrous to consider how the tail often wags the dog, but it is true, and the situation often develops similarly in business. Ours is a domestic business. Foreign relations should not dominate us to the extent of determining whether we should profit or lose; they will determine to an extent the amount of our profit.



We must each undertake to make *certain* that the spirit of progress and business activity possesses the people with whom we come in contact. Bumper crops; hard work; transportation systems; great cities; commercial enterprises—all are built first in the mind—in the minds of communities—and afterward comes the call for crushed stone.

We have the call on the gold of the world. We have the credit. We have the *necessity for building*—improving, modernizing, and the year 1923 should make records to look back upon and be proud of. And each of us should do his share and receive his share.

Salesmanship should be stressed, and the work of the salesman kept ever ahead of the plant operation. Excess of production over selling capacity in the organization means ultimate loss, not only to the individual company but to the industry.

Coal is not in the center of the stage this year. There is a possibility that it may assume a dominating position through the fact that certain of the United Mine Workers'

officials are dominated by the desire to put over a program of nationalization. As you value the right of American initiative and property rights, you should combat this tendency toward sovietism at every opportunity.

Without a strike, coal costs cannot be reduced by the operators in the union fields. A general strike is unlikely. A reduction of wage in non-union fields compared to that which occurred in 1921 is not probable. The large losses sustained by the miner in the strike of 1922, followed by slack working time, on account of lack of cars, have reduced his earnings until he will be easy prey to the agitator, and local, or wildcat, strikes may be expected. It is always wise to have a coal supply in the possession of the consumer.

Transportation is the key to your success in 1923 and the future—plus our own vision and spirit of optimism and determination and our own hard work. While we are apt to think of transportation in terms of "cars furnished," still, the stone industry can afford to be actively for and cannot afford to oppose or delay any practical highway or waterway program.

The railroad companies are going to be in a position to furnish us equipment this season largely in proportion to the failure of general economic adjustments abroad.

Our certainty of success lies in our utilizing the probable plentiful supply of equipment early in the season without committing ourselves to an unprofitable basis of market, should shortage of equipment later in the season greatly restrict our operations.

Discussion of Transportation

By P. C. Hodges (Marble Cliff Quarries Co., Columbus, Ohio)

IT seems to me that the greatest hope held out to the manufacturers producing commodities moved in open-top equipment lies in the solving of the coal problem that is now up to the United States Coal Commission at Washington. A Fact Finding Commission has been appointed to delve into all angles of the coal situation, and I would just like to read here a statement given to the Coal Commission yesterday at Washington by the American Railway Association which, I think, will prove conclusively that the solving of that problem will, to a great extent, eliminate our difficulties in the car situation. I will not read it all, but there is some of it that is most important.

As to how the mining industry through over-expansion keeps piling up car shortage, the report calls attention to the fact that in 1920 a total of 14,766 bituminous coal mines were in operation, an increase of 154 per cent over 1910. Coal production, however, increased only 37 per cent. With an increase of 154 per cent in the number of mines in operation, the coal production increased but 37 per cent.

"If the 1910 tonnage production per mine had been maintained in 1920, the tonnage of that year could have been produced by 7050 mines instead of 14,766." This means that the railroads were called upon to divide the available cars among 6800 more mines in 1920 than would have been necessary if the average production per mine had been maintained on the 1910 basis.

"It means that 150,000,000 tons, by which coal production in 1920 exceeded 1910, were gathered from 6800 additional mines, calling for vastly increased motive power, coal car supply, and man power for the railroads to serve them all. The expansion was not confined to the increase in number of mines. The number of cars ordered, based on the rate of ability of the mines to produce coal, kept pace until in 1920 the mines ordered cars sufficient to load 830,000,000 tons, which was 46 per cent more than the total consumption of the country. Showing the peak demand after settlement of the coal strike, figures are given that last October and November the mines of the United States ordered cars for 165,000,000 tons, which was at the rate of a billion tons per annum, or at the rate of twice the annual consumption of bituminous coal.

"In the 10 years the railroads increased the tonnage capacity of their coal cars by 42 per cent, while the tractive power was increased 53 per cent, in comparison with an increase of coal production amounting to only 37 per cent. This favorable tendency, however, was bowled over by the increase of 154 per cent in the number of mines requiring a greater amount of transportation service."

Now it seems to me that it is very evident that here is where we have the greatest hope in securing some satisfactory solution of this problem.

The Interstate Commerce Commission, under the law, of course, is permitted to deviate from the established principle of non-discrimination in the case of an emergency; that is what they have always done on the coal car supply. They have not been taking into consideration the above economic condition. It is very likely though, I think, that something will be done to curtail the transportation that is required by these coal mines. You can readily see the number of cars that are taken out of service from other business when the coal mines are reordering and declaring that they need almost twice as many cars as it actually takes to serve their own industry, and the Interstate Commerce Commission faced by such a demand, slaps on a priority order to supply this fictitious demand. At the same time the attempt to furnish these cars to double the number of mines necessary to supply the coal, requires much additional transportation and uses up all the carriers' facilities to the disadvantage of all other shippers.

Valuation of Stone Deposits

By Joel H. Watkins

Mining Geologist, Charlotte C. H., Va.

IN its relation to capitalization and development, the valuation of a stone deposit is, if anything, fundamental. Strange to say, however, it would seem to be about the last thing thought of by some of our friends of the stone-crushing industry. No doubt, many of the stone-crushing enterprises of this country have been the outgrowth of local and intermittent demand, and have been started in a small way. Stone deposits of any magnitude are, generally speaking, more or less visible at the surface. For an initial output, therefore, of limited tonnage, the erection of a small crushing unit has in most cases probably been justifiable. Many of these initial plants have been enlarged from time to time until their capacities have been greatly expanded.

The rapid growth of our towns and cities, the thousands of miles of railroad ballast, and the ever-increasing demand for crushed stone for highway and general concrete construction have all helped to bring the stone-crushing industry to the front as a sound and permanent business. A large number of these stone deposits are well located with regard to market conditions and have valuable tonnage reserves.

Time to Find Out What Deposits Are Really Worth

To some of us at least it would seem that the time has now come when an inventory, so to speak, of such deposits should be taken and a present value placed on their stone reserves. Such a valuation should in most cases be based upon geological investigations, accompanied by detailed geological maps and sections, so as to illustrate thoroughly the extent and character of the deposit under consideration. As compared with metalliferous ore deposits, the geology of stone deposits is comparatively simple. With perhaps few exceptions, all of the stone produced by the crushed-stone industry is won by open quarry methods.

In general, stone deposits may occur as massive bodies without strike, dip, or bedding planes, as in the case of unaltered granites, diabase (trap rock), and other rocks of igneous origin; they may be flat lying with distinct bedding planes of meas-

urable thickness, as in the case of limestone, sandstones, and other sedimentary rocks; or they may be folded and distorted until the workable beds are pitching at almost any angle from the horizontal, as in the case of both metamorphic rocks and unaltered sedimentary rocks. These are but elementary and simple facts to the geologist, but to the layman, the quarry owner, they seem to impart some mystery of dubious import.

Some quarrymen, through constant observation of their own stone deposit, become convinced that they, better than anyone else, can interpret its geological significance. They will speak knowingly of such much-abused terms as strata formations, and upheavals, and at the same time fail to observe some of the most obvious facts written in the rocks. Please bear in mind that when I speak of geologists, I refer only to men who are thoroughly trained in their profession, who have had wide and varied experience, whose judgment is sound and mature, and who are honest in their opinions.

In America, the profession is well supplied with men of this type, but unfortunately quarry owners do not, as a rule, come in contact with such men often enough to appreciate their worth. I am afraid that it is too often the case that when executives of the stone-crushing industry make up their minds that they need the services of a geologist, they cast about and finally engage the services of an incompetent man who does not possess the knowledge and experience so necessary in imparting to the owners the information which they desire and deserve.

I would therefore base the valuation of stone deposits on the following considerations in the order of their importance as I see them at this time:*

Crushed stone is classed as a low grade commodity—that is to say, the margin of profit per ton is usually small. As a dividend producer, therefore, a crushed stone proposition is only attractive when its daily production is large and the stone reserve is adequate. Take, for example, a crushed-stone plant of modern design and equipment, and say of 1000 tons daily capacity. Capitalization of such an enterprise should be based on not less than 25 years' stone reserve which would be depleted under the continuous operation of the plant at capacity. Amortization should be at such a rate as would insure a return of the initial investment in not more than 15 years. Should the plant capacity be 2000 tons daily, for the same body of stone, valuation should be in proportion to the increased capacity and earning power, and amortization in proportion to the shorter life of the quarry.

In order that the available tonnage of stone within a given area be measured with a reasonable degree of accuracy, the deposit should be visible on at least four sides, or there must be abundant geological evidence as to the extent of the deposit, upon which dependable estimates may be based.

One of the first things that a valuation engineer wants to see when he approaches the task of preparing a report on a stone-quarry property is a drawing or blue print, showing accurately the boundary lines of the property which is to be studied. Such a map should not only show property lines, but should show all buildings, roads, streams and rail tracks, and also a topographic sketch with contour intervals of not less than 5 ft. The preparation of such a base map is plainly the work of a civil engineer, and should not be expected of a geologist. My own observation has been, however, that few of the stone quarry companies have really good base maps, and almost none of them have topographic maps. To attempt to prepare valuation reports without base maps is placing a handicap on this work which is an injustice to the valuation engineer, and detracts much from the usefulness of his investigations.

In measuring a stone deposit, therefore, it is desirable to have good base maps, upon which, and with the aid of geological sections, both the lateral and vertical extent of the deposit can be shown. Such measurements must take into consideration both the thickness and character of the overburden, the depth to which it is at present practicable to quarry, the varying elevations of the surface overlying the area of workable stone, the thickness and dip of workable beds, should they be overlain or underlain with undesirable materials, and the depth to which it may be practicable to work the deposit at some future time.

Characteristics of Rock Deposits

Some simple features may be mentioned here which have a geological meaning, and which also have a bearing on the quantity and availability of stone deposits. As has been stated, some stone deposits are massive in form and show no bedding plans or lines of rock cleavage. All rocks, however, and especially igneous rocks, are divided into large and small blocks by systems of cracks and crevices known as joints. Jointing is usually highly developed in basaltic rocks, commonly known to quarrymen as trap rock.

These systems of joint planes which cut the rocks at various angles are in almost every case a help to the crushed-stone quarryman in breaking down the stone, but in many cases they are a hindrance to the dimension stone quarryman in getting out blocks of marketable size. Where the stone is massive, the overburden, which must be moved before hard fresh stone can be reached, is almost invariably residual clay, or some weathered or semi-decayed rock, unless the overburden happens to be an alluvial or glacial deposit, which is transported materials, and not derived in any way from underlying rocks.

On the other hand, limestones, as a rule, do not decay or disintegrate, unless they are very impure limestones, and carry a large amount of clay substance. Limestones are simply dissolved by the weak acids carried in solution by surface waters, and leave behind a mantle of residual clay which represents the iron-aluminum-silicate content of the original rock. Under ordinary conditions, erosion carries off much of the residual formed in this way. Limestone deposits, which are subject to erosion, therefore, generally have but a light mantle of clay. This is particularly the case in the colder climates, where erosion usually keeps pace with rock weathering.

Every quarryman who works in limestone, however, is familiar with pot holes, mud seams, and sink holes, which often carry the stiff red clay deep into the face of the quarry. I have seen limestone deposits being worked which showed almost no residual clay, but which were covered with a mantle of alluvial clay from 20 to 50 ft. in thickness, as in the case of the limestone deposits along the Mississippi river north of Alton, Ill. Again I have seen limestone beds which were barely exposed in a few places at the surface, and still the workable stone began but a few inches below the grass roots, as in the vicinity of Bellefont, Center county, Pennsylvania.

Mining of High Grade Limestones Will Increase

Where the limestone is being used for lime burning, as furnace flux, and in the manufacture of portland cement, there are a few locations where the stone is won by underground mining methods. Though such cases are limited in number at the present time, my prediction is, that as time goes on, the number of underground operations of this class will increase from year to year, due to the fact that some of our most valuable deposits which are close to large and permanent markets, are being steadily depleted of stone, available at or near the surface. There are cases which have come under my observation where the use of a drill has been found to be quite necessary in order to determine the extent and character of the stone where it has not been exposed by nature or by present quarry developments. Such exploration work may be accomplished with use of either core drill or churn drill, but the core drill is generally considered more desirable, as the core taken out, foot by foot, affords a better means of both physical and chemical examination of the rock than does the pulp from a churn or well drill.

In order to determine the quantity of stone within a given area, which will be available under different conditions of operation, as many measurements should be taken, both laterally and vertically, as practicable. Use should also be made of all geological data which are evident, and which have a definite bearing upon the extent of the deposit. When such information is carefully plotted upon geological maps and sections of good scale, they afford the quarry

*In arranging the order of these considerations, I was aided by suggestions from my friend Charles Catlett of Staunton, Va.

owner and the banker a graphic illustration of the stone reserve and of the physical conditions of operating which they can comprehend in no other way.

The physical and chemical properties of stone which determine its quality are as important, in a way, as quantity. For example, there are many localities where large deposits of stone occur close to market, but which are of no commercial value on account of being unsuited for any of the ordinary uses of crushed stone. In the Appalachian states one of the predominating rock types of the crystalline area is mica schist. This rock, especially where it is high in mica content and breaks into flat lense-shaped fragments, is unsuited for either road metal, railroad ballast, or concrete construction. Some rocks are hard when freshly broken, but disintegrate quickly upon exposure to the atmosphere. Some limestones are impure, soft, and shaley, and are undesirable for almost any use.

I feel that this discussion should have to do chiefly with crushed stone for construction purposes, though I realize that many lime, cement, and fluxing stone companies also sell crushed stone in large quantities. The chemical composition of rocks, which may be used as crushed stone, effects their value only insofar as their physical properties are concerned. The hardness of the stone and the manner in which it breaks have much to do with its ease of production and its desirability.

For example, quartzite and diabase, two of our hardest rock types, generally break into sharp, angular fragments, and are admirably suited for railroad ballast and concrete construction. On the other hand, the cost of drilling and crushing these two types is so much in excess of the same cost items in other types of rock that they necessarily demand a higher selling price in order to show a reasonable margin of profit.

There are throughout this country today, and probably in every state in the East, monumental examples of failures due to physical and chemical properties of stone which were not judiciously taken into consideration before work was begun. I know of one example wherein one of our trunk line railroads, needing ballast in one of the states traversed by its lines, first opened two large quarries, both in mica schist. This rock was fairly easy to drill and crush, but unfortunately it broke into lense-shaped fragments, all of which were coated with fine scales of mica.

These quarries were operated for a period of years, and a considerable mileage of the railroad was ballasted with this material. Though it seemed to take a long time to soak in, those in authority finally came to the realization that the mica on these lenses of rock was acting as a lubricant, and though wedged in tightly by constant tamping of the section men, the ballast had no binding properties and would soon work out of place.

A quartzite quarry was next opened, but due to the hardness of the stone this quarry failed after a period of expensive operation, when the discovery was made that good stone could be purchased nearby for less than it was costing to produce the quartzite. Their next venture was to give a large contract for ballast, and to subsidize the contractor who was operating a quarry in red Triassic shale. This shale was easy to drill and crush, and was fairly hard when freshly broken. After a year or two, however, the shale began to crumble and disintegrate into a clay-like substance.

To relieve this situation, a fourth quarry was opened on a large butte of diabase within about one mile of the main line of the railroad. Although this plant was new, and had ample trackage facilities, it was foredoomed to failure, as the rock was even harder to drill and crush than the quartzite. The irony of the whole situation was that all this time there was a perfectly good deposit of excellent ballast rock directly along the tracks of the railroad and at a central location.

Many parallel cases of the unfitness of some stone deposits for the economic production of crushed stone may be given here, but the above examples should serve.

Ease of Production

There are certain elements in every quarry operation which have much to do with the cost of production, but which may vary for different localities. Any feature which has to do with the cost of production has also to do with the earning power of an enterprise. These are physical features, some of which may be enumerated here without going into detail of example. The hardness and breaking properties of the stone, mentioned in the last paragraph, has to do with the cost of production. The amount and character of the overburden and the distance to which it must be moved are variable elements of cost. The workable thickness of the stone itself and the amount of drilling and powder required per ton of stone produced are elements of production cost. The amount of water to be handled and the ease with which the stone can be moved from quarry to crushing plant are elements of cost. The topographic and structural features of every quarry either add to or reduce the cost of production, as the case may be. The ease of physical production is therefore another factor which must not be overlooked when considering the value of a stone deposit.

The question of nearness to market and to transportation is one of inestimable importance. It matters little how large a stone deposit, how desirable the physical and chemical properties of the stone may be, or how cheaply it can be produced if it is so remote from a permanent market that the cost of transportation absorbs all of the profits. It is plain to see that a stone proposition which can deliver into a consuming market at 5 cents per ton less than a competitor is worth 5 cents per ton more at the point of production, all other things being equal. The matter of cost of transportation therefore makes economic production of some stone deposits prohibitive, at least under present conditions. Here the value of a stone deposit is again reflected in its relative location with respect to market.

Any stone deposit which is isolated, and is close to a strong market, has, of course, special value. If on the other hand it is surrounded by similar deposits, with equal working conditions and large stone reserves, the question of valuation must be based largely on its relative stone reserve, and upon the price at which any or all of the properties can be purchased. Invariably, one of the first considerations that confronts a party who seeks a location for establishing a stone-crushing industry is the matter of competition. What he naturally wants to find is a location where, all other things being equal, he will at least have a market for a reasonable portion of his output.

Where two or more stone-crushing companies are operating on the same body of stone, having the same physical conditions, the same labor conditions, and the same market, if one company outstrips its neighbors in economic production, the reason for greater efficiency can be quickly traced to superior equipment and management. The relative abundance of stone, therefore, in a given locality, unless it is all controlled by one company, has an important bearing on the value of individual deposits.

Conclusions

Much has been written on the valuation of ore deposits, but I have seen but few references to the valuation of stone deposits. It is evident that there can be no definite formula for the valuation of either mineral deposits or stone deposits, but there are many things in common which have to be taken into consideration. Everyone knows that capital, plant design, and management have largely to do with the successful operation of any undertaking, but I do not feel that these factors have anything to do with the value of the stone deposit itself, and therefore should not be open for discussion here. An active quarry operation, like a mine, is subject to continuous depletion.

I feel that the points brought out in this brief paper, though elementary, are pertinent, and should be suggestive to those who have not given serious consideration to the matter of valuation. Though a few examples have been given above, each quarry proposition has its own peculiar features and its own individual problems. It is evident that such factors as are mentioned above, and which enter into the valuation of every stone deposit, must vary widely with different properties and different localities. Wide experience, keen observation and mature judgment help to reduce the error in such calculations.

Jack H Watkins

What a Banker Wants to Know About a Quarry Industry

By J. E. Lindquist
Vice-President, Central Trust Co. of Illinois, Chicago

I AM invited to this meeting simply because I used to be in the stone business. Now whether that qualifies me to address you gentlemen, I don't know, but I shall endeavor to do the best I can.

The previous speaker mentioned something about the stone quarry man not knowing himself. That is absolutely true, and I speak, of course, about the Central West. They don't know their own problems, or didn't up to the time that I left the business, which was in 1909.

Bankers, as a rule, look with a great deal of distrust upon any enterprise where there are any quarry operations involved. Nevertheless, we have been able to place the quarry situation before bankers in a manner that now receives their support as it should be received. I have in mind being requested by other institutions to appraise quarry properties, and to lay outlines of procedure to negotiate quarry financing. Years ago that was an unheard of thing.

In undertaking the presentation of a problem of this character, permit me to suggest that what I may say in connection with the matter is, in the light of past experiences, somewhat limited, and covers refinancing rather than underwriting new ventures. A new venture is rather an undeveloped proposition. You build a plant in a verdant place; you have no quarry. How can a bank finance an undertaking of that kind? Quarries are developed as time goes on, and in that way banks cannot, and I never heard of any bank that ever did, in this section of the country, finance a new venture of that character.

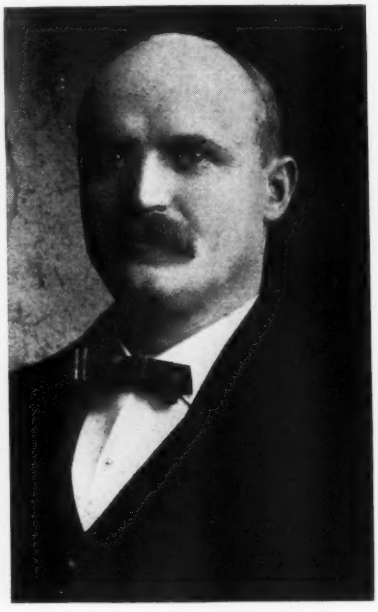
Quarry history in the Central West points to the fact that very few enterprises today are being operated by original owners, indicating a lack of intelligent quarry management, due to either one cause or another.

Information and data required could be summarized about as follows: History of the company, purpose of financing, valuation of security, survey of market conditions, income record, and general information.

Valuation of Quarries

On the valuation of security, an expert and detailed appraisement by a competent engineering company would be required, covering structures, machinery, electric plant, railroad and equipment, quarry lands and miscellaneous.

The survey of market conditions should be careful and accurate and a direct survey of the market possibilities, the support of quarry plant, should also be obtained from authoritative sources. Many enterprises of this kind have undertaken to refinance without going into the question of market possibilities. Draw a circle of a hundred miles around your quarry. I wonder how many in this room know what their market



prospects in their different localities really are. If I were to build a plant or take over a plant in Louisville, Kentucky, I surely would look into the market conditions before I would undertake to even buy shares in that quarry or plant.

Developing a Market

I know when I was in the stone business I had the output of several large quarries in this section—nine, if I remember rightly—and as a matter of information, I might say that we handled in the neighborhood, in the latter part of my term, as much as 2,000,000 yd. a year. We employed 700 teams. I didn't have a single salesman. We handled the product from the quarry to the building or to the pavement or the enterprise for less than five cents a yard—I mean overhead expenses. In fact, we paid monthly dividends upon that operation. In addition to that, we had what I would call a promotion office, run entirely separate, and I give you these facts because they are real facts, for the working up of new business.

In those days if anybody mentioned building a country road, he would be shot by the first farmer than ran into him. Today, of course, the country road is established. I remember writing to Congressman Madden in Washington and asking him to undertake to have a bill presented in Congress for federal aid. He wrote me and said: "Lindquist, the man who presents that in Congress will be run out." It remained for a United States Senator from Alabama, who, about 1908 or '09, I don't remember which, introduced the first federal aid bill in Congress. My friend Madden lost a wonderful opportunity of being father of the federal aid law that was subsequently enacted.

In this promotion office that I mentioned I had solicitors out to introduce various methods of pavement throughout the sections of this city; without somebody taking an interest in the work and promoting it, there wouldn't be very much paving done in a place like this or any other place for that matter, as near as I can tell. We paved as many as 130 miles of roadway in this city in one year. Last year, I think the City Hall records indicate that 98 miles were paved. All that required attention on the part of somebody, and that somebody was the man who furnished the material and no one else. It must have been either the cement man, the stone man, or the brick man, if it was a brick pavement, or the asphaltum man if it was an asphalt pavement, and so on down the line.

Promotion is an essential thing, to my mind. I imagine now that you boys can sit back in your chairs in your home offices and just wait for business to come to you on account of the fact that there has been a great deal of agitation for highways, but let me tell you, you never want to lose sight of the fact of encouraging that work continuously; organize for it in every way that you can. It can be done and should be done.

Income Record

The earnings covering a period of years should be submitted, indicating the manner and method of arriving at the same, and showing the proper depreciation of plant and the depletion of quarry lands made during the period under review. Where you quarry men have an income (of course I mean a profit) you will take mighty good care now to take advantage of those two items because they are allowed in your income tax return, but prior to the income tax record, I never was able to find any quarry man that ever took into account any depletion of quarry or depreciation of plant.

It is an advantage, of course, as I say, where you have earnings, to make a proper allowance for this so that your tax will not be so large.

General Information—Good Management

The final subject which is of vital importance covers first the matter of quarry management, which must be under the supervision of the superintendent of the highest type and especial ability. To my mind, a high-grade, first-class quarry superintendent who understands every angle of the business of production is more important than a high-priced sales manager. I recall placing a half-million dollar bond issue on a certain quarry. I investigated the management of it and I made the quarry owners negotiate a contract with the superintendent for the period of time for which the mortgage ran, because it was an insurance to us to know that their quarry was properly managed and that it would be on a profit basis under that management.

To obtain the maximum of production at the minimum cost and at the same time improve the physical quarry conditions for future economical operation is the life of the business. Upon the superintendent depends or devolves the matter of stripping, blasting and producing tonnage so that the plant will reach its highest producing capacity each operating day, which would result in earnings to not only support any banking investment, but to assure the stockholders the payments of dividends.

Now I don't know of anything else that I can add to the matter which has been assigned to me. I am sorry I can't go into it more thoroughly and more fully, but I certainly want to express to this body my appreciation for the opportunity of being here today and addressing you on this subject.

CHAIRMAN SCHMIDT: Mr. Lindquist, we appreciate the message that you have left with us. Are there any questions that you would like to ask Mr. Lindquist? He has been through the game.

THOS. SULLIVAN (National Stone Co., Omaha, Neb.): How much a ton depletion is usually allowed?

MR. LINDQUIST: That depends entirely upon the conditions. There is a certain amount per yard allowed by the United States Government. I was in conference with them several years back but I don't recall just what the figures were. They can be obtained from the Internal Revenue Division of the Government, I am sure; that is, the maximum amount allowed.

I don't want to use the personal pronoun too much, but you know when a fellow has been in the business of stone he has graduated from almost the worst game in the world, and if he comes out of that with any hair left, then he is lucky; but he certainly is qualified for anything else if he has been a careful, cautious student of the stone business. There is the element of chance, but it is a very enticing game. Frequently I go through quarries simply as a matter of pleasure, to see quarry development, to analyze the situation, but I want to re-emphasize the fact that the production end of your business is the heart of the whole thing.

A. A. HALL (Ohio Marble Co., Piqua, Ohio): I would like to ask the question, from your viewpoint, of what the banker considers the value of opening a quarry. You made the remark a while ago that after the building was up and after the plant was in good shape, they still didn't have a quarry. How much of an allowance would they figure from the opening of that quarry on one which had been in operation?

MR. LINDQUIST: I might say until a quarry is fairly well developed, there is no allowance made, unless there has been a careful examination made by borings and other methods to develop a proposition. A quarry is made not in a month or even in a year, but it is made by successive years of operation, and the man that runs a quarry that can't see two or three years ahead is no quarry man.

Research and the Crushed Stone Industry

By James R. Withrow

Professor, Industrial Chemistry, Ohio State University

IT was a great pleasure for me to assist your research committee in a small way and it has been very interesting for me to listen to the important papers that have come before this convention; in fact, it has been very instructive to me.

Naturally, many questions arise in your minds when such a report as presented by

James R Withrow

your committee comes before you. It is very natural that you should ask, "What could a research program do for me? Is it not a local matter? Can research benefit this organization as a whole?" The answer, in my opinion, is, "Yes, it can."

There are great differences, it is true, in the problems in different portions of the stone-crushing industry. Research can help each of these individual cases. It would be foolhardy to say just where and how without a complete discussion of each of the cases. However, research can help the industry as a whole in exactly the same way as this organization helps the individuals as well as the industry as a whole. One great possibility, for instance, is sufficient to mention. It will, in my opinion, establish a recognition by the public, and government agencies as well, of the importance of the crushed-stone industry to the nation, to business itself and to civilization.

Now what is research? Research is no mystery; it is rather the elimination, or a method of elimination of mystery. Business is like an army; an army operates on its stomach; business operates on experience. You are in business. Research simply means fact finding and fact organization. It is the rapid accumulation of experience and its organization for future usefulness.

I was talking only last week to Wilbur Wright, whose success in his work of developing the airplane is well known to everyone, and Mr. Wright made this interesting statement: that if his father had been a business man he never would have flown, simply for the reason that at very few stages of the experimental work of himself and his brother would he have been able to show that what he was going to try would pay. And so it was interesting for me to find out that Mr. Wright had disposed of all his personal holdings in the various Wright companies quite some time ago and was devoting his time again to his old love, namely, simon-pure research and experimentation. He said there was but one idea that they had, namely, to find out just how to do this trick that was before them and not any idea that it would ever be useful, for they apparently did not have that vision. "But the success," he said, "that we have today,

which is a phenomenal thing, and which you and I could not have predicted 20 years ago, was due to these investigations, this research."

That is one of the fundamental things about research, you can't predict where it is going to lead you. The fact that it does not appear to pay at first is no sure sign that it will not be eventually of great value.

Another case that everyone of us knows about is the wonderful development of so-called radio—wireless telegraphy—and so on. Twenty years ago you and I had no idea of such a possibility as actually speaking across the ocean or receiving messages through the air. It was well known at that time that there were waves that could be propagated under certain conditions—Hertzian waves—and an immense amount of investigation was carried out merely for the purpose of finding out more facts about them; but no one at that time was able to predict that they would be of any use, and now we know the inestimable value that they have.

Now like every other business, you stone men will ultimately come to the research basis. In view of the things I have said, it is the only sound business basis, so I will drop its direct discussion.

What Is the Stone Industry?

My personal interest in what you do about research is very small. I happen to have a job and I am not looking for a new one. As a professor of research engineering, however, in a great American university, I have a great interest in problems and in the dignity of industry, and in yours as a basic one.

Let us consider what this business of stone means. What does stone mean to mankind? I jotted down the other evening just a few ideas that occurred to me as I was thinking about this and if you will pardon me for a few minutes, let me tell them to you.

This age in which we live is the stone age. I know that the dictionary and the encyclopedia will tell you that the stone age was a period long ago when man seems to have depended upon stone for his tools. That is all they know about it. To them it is merely an archeological term. Archeology claims that man made his fighting arms of stone in that age, and various races and tribes have actually brought this stone age to our own time. When the Indian or the African or the Polynesian felt the need of tools, he crudely formed them of some stone. Having none of our mechanical or engineering equipment these benighted tribes did not get far with the use of stone.

That was not the stone age which archeology talked about, it was merely the crude state to which portions, at least, of mankind were reduced, in which they could only avail themselves of those assets in nature which were and still are most fundamentally important and valuable to life. They made their tools of stone because it was the only material or the best material which they could manipulate. It was, therefore, the material of most fundamental value to them for this purpose; nevertheless, they did not use much of it. They did not possess the power to do so. A carload would outfit a town or a tribe.

In the extremity to which these portions of mankind were reduced it was not likely that they used stone even for shelter except when they hid in a cave. It is civilization only that could make proper use of stone, and it is a highly organized industrial civilization only that could make use of stone to the maximum potential value to mankind. Even the highly developed civilization of Asia, of Egypt, of Carthage, of ancient Greece, and Rome and medieval Venice and Florence failed to get the most even out of the beauty of stone.

As a matter of fact, there are many things of importance in the modern industrial development of our civilization, but nothing that we have today is as important as stone which, to them, was also fundamentally important.

A Vitally Important Industry

If the ancient times or the crude levels to which some of mankind are reduced have been called the stone age, is not this, our age, much more the stone age? We use stone to a colossally greater extent than these ancients ever dreamed. The amount of stone used in modern communities is astounding. Then, too, we use stone for a vastly greater variety of purposes; in fact, I am sure it could be demonstrated that while in the stone age man prized stone, he could really do without it, whereas, in our day, just imagine the situation if we were compelled to abandon the use of crushed stone. If vital need, then; if power to utilize as never before, if we choose; if varied uses; if volume used, mean anything, *this is the stone age.* Stone and the stone industry have great dignity. Evidently, stone and the stone industry have always been of much concern to mankind. At any rate, these materials and this industry have all the dignity which is associated with antiquity and human needs and human interest.

The ancients lacked the power to properly use stone for man's most good, but we have that power. Now we want to know whether we are using all of the power that the human races possesses. We should look upon research as an insurance to this end.

Perhaps I can give you an illustration before I stop as to the meaning of crushed stone to me. I am not a crushed stone maker, though I have been in more of the quarries of you men that you imagine. It used to be a hobby of mine to collect mineral crystals—it still is, although I don't have much time to work at it; I have been in many quarries from Massachusetts on the East, through New Jersey, Pennsylvania, Ohio, clear out to the Pacific Coast. But crushed stone means this to me: it means wonderful ability to do things in a short time that the ancients couldn't do at all with all their skill. The Romans were wonderful military engineers. You go to Rome and look at the Colosseum. There is only a third of it and yet it is the greatest monument in the world today. It took Titus 12 years to build the Colosseum. He brought 80,000 Jews from the capture of Jerusalem and told them they were free when they built that affair. It took 80,000 men twelve years to build it. They had no crushed stone, or practically none, for they had no tools to make it. That Colosseum is built of solid block and of brick and of their cement which they discovered. Now the outside circumference of that Colosseum is practically identical with the outside circumference of the great stadium that was built by the Ohio State University last year, but in that stadium of ours we have a football field over 100 yd. long and 50 yd. of space at both ends, and on each side it is about 50 yd. wide. Those are roughly the dimensions.

The Colosseum has about the dimensions outside as this stadium of ours, and the Colosseum held 84,000 people, roughly what ours holds, but we couldn't get a football field into the Colosseum in Rome because that arena is only 97 yd. long and 47 yd. wide. It gave much less space to get the capacity. They had to go way out on the gridiron, so to speak, in order to get the seating capacity. Why? Simply because they didn't have two things: structural steel and crushed stone. Crushed stone enabled us to build that stadium in one year with 200 men. That is because we have acquired additional experience and power in science and engineering, those two things working hand in hand and side by side.

Conclusion

In conclusion let me state that we have outgrown a lot of our old ideas. I believe you have, too, for we are always outgrowing them. We can't predict ahead, very many of us, what is going to happen next year. We are always surprised at new developments. I don't want you to be in a situation that was the case with two men I heard of years ago. One of them was a Congressman from North or South Carolina. About 1830 he made a speech in Congress in which he thanked God that there was the Rocky Mountains to prevent the further expansion of the United States. The other was a commissioner in the United States Patent Office who resigned two years before the first Bell telephone patent, because he said he didn't like to take his salary since all important inventions had then been patented. Now those were both good men, but they could not see ahead because they didn't understand that active wills and active minds would always be doing new things and you and I can't dream what they are going to be. It is imperative, therefore, for the self-respect of any industry that it get on the research basis; all modern business must do so. Research is insurance. It is a tool to insure our development in the future.

Report of Committee on Research and Trade Extension

GENTLEMEN, your committee recommends:

1. That a Bureau of Research and Trade Extension be established by the National Crushed Stone Association.

2. That the chief function of this Bureau shall be the locating of reliable, dependable information and the distribution thereof to our members in such form as to make it readily accessible to the non-technical owners and operators.

3. That this Research and Trade Extension project be developed gradually and not too extensively, to avoid unnecessary expense from the very beginning.

4. That the sum of $15,000 per year for two years be set as the limit of expenditure in this undertaking.

5. That the work of the Bureau under this project be under the supervision of one chief and be organized in two divisions:

Division 1. Statistical and Investigational.

Division 2. Publicity and Trade Extension.

6. That no time be lost in getting under way with this project.

Now, gentlemen, with these recommendations before you, we are in position to discuss the whole project.

Organization and Work of Your Committee

You will remember the paper I presented at our annual meeting, held a year ago, and on the strength of which I was instructed to form a committee and investigate and report on the value and possibilities of a Research and Trade Extension Project in this, the National Crushed Stone Association.

My first step was to select members for this committee.

The committee as constituted consisted of W. H. Hoagland, Marble Cliff Quarries Co., Columbus, Ohio; J. J. Sloan, the Wisconsin Granite Co., Chicago, Ill.; John Rice, the General Crushed Stone Co., Easton, Pa.; Nathan C. Rockwood, Editor ROCK PRODUCTS, Chicago, Ill.; Harry H. Brandon, chairman, the Ohio Marble Co., Piqua, Ohio.

In making the selection of the comittee, I tried to select men who were representative of the general groups of producers represented in our Association, and men who were thoroughly interested and capable of offering worthy assistance.

At a preliminary meeting of this committee it was found that the work proposed was of such a complicated and limitless nature that expert professional assistance would be necessary to keep it within practical bounds.

Dr. W. C. Thompson, president of the Ohio State University, was enlisted in our cause. He immediately became interested and offered to us all of the assistance of his wonderful school. He delegated to us the services of Dr. James R. Withrow, Director of Industrial Chemistry and Chemical Engineering.

Dr. Withrow has met with our committee consistently and has certainly been the guiding light in the preparation of this report. His broad experience and knowledge have directed us away from the many pitfalls we might have incurred had we not been so ably assisted.

Reasons for Our Recommendations

We have a number of very excellent reasons to offer why this project should be undertaken in the manner suggested:

1. Our crushed stone industry is already late in arriving at the well-traveled road of research. We have therefore the excellent example of other industries which have previously seen this same possibility in their businesses. It is not necessary to go into detail regarding the wonderful results of the operation of the Portland Cement Association, Face Brick Manufacturers' Association, Paint and Varnish Association, and many others.

Evidences of Wasted Over-Production

2. There are evidences of wasted energies, shown by accumulation of waste piles which, in their tremendous size, disfigure the appearances of most quarries.

It has cost an equal or greater amount per ton to place this material in these piles than the actual per ton cost of finished product.

The amount of money spent by the members of this Association in the past five or six years either in storing or in attempting reclamation of this waste material would have paid the cost many times over for this project.

In these times of high cost production it is becoming a serious menace to the crushed stone business to have to absorb the cost of producing these wastes.

Every existing hope of eliminating or utilizing these wastes must imperatively be investigated and if no hope presents itself we must invent relief, individually or collectively, before very long or some of us must close down production.

3. The modern trend of industry is toward the elimination of these wastes. We do not want to be the last in the line of progress. We should have been pioneers in this wonderful work of waste elimination.

4. Industrial progress and civilization are frequently tied up with the result produced by the initiative of some alert individual producer. Many things that have registered their importance in the history of civilization have been brought about by some individual being sufficiently wide awake to find some method of disposal of over-production or waste products. Much of our great chemical industry is based on by-product or waste utilization. Glycerine was for long a waste from soap manufacture. Someone made nitroglycerine from it, and now we clear our farms and run our quarries and mines with it or its related explosives.

5. The associations that have taken up these projects in the past have the satisfaction of becoming much more important factors in modern industry and are regarded with greater respect than would have been possible for any individual. The members of these associations have profited in direct ratio to the progress and initiative of their organizations along this line.

Reasons for a $15,000 Two-Year Budget

The $15,000 per year would cover a budget as follows:

Services of a part-time chief for the sum of approximately	$4000-$5000
Services of two investigators at $2500 to $3000	5000- 6000
Traveling expenses	1000- 2000
Laboratory, office space, stationery, postage, stenographer, printing, miscellaneous	2000

Looking at this as a five- to ten-year program, it would be much more efficient to go into the matter at once, but slowly, for the reason that an expensive organization could not function properly at the start. Certain preliminary work of a time-consuming nature must be first completed, such as collecting and compiling statistics and their authority; developing points of attack where the Association as a whole would profit; the formation and development of plans for campaign of activities.

There has undoubtedly been some considerable, though spasmodic, effort made along similar lines, therefore we should collect and compile what has been already accomplished before we go deeper into other forms of productive work.

It would be expensive, and nothing would be gained for us to cover ground and secure information that is already available for the mere cost of collecting and giving publicity to the Association members.

As a matter of fact, it is anticipated that if the work is taken up gradually in this way by a systematic, carefully considered plan of action, the expenditure for even the future phases of this work can be kept

down to a surprising extent without affecting the efficiency of the work itself.

It is a vital necessity, if this program is attempted, that our chief be a man of unusually high caliber, a man thoroughly experienced and capable of entering a tremendous work of this kind in an efficient manner.

The entire success of this program depends on two things:

1. The financial and moral aid of our membership.

2. The ability of our chief.

The chief function of this Research Bureau should be the locating of reliable and dependable information and its distribution to our members in such form as to make it readily accessible to the non-technical man.

The engineering investigators of the Portland Cement Association were given financial and moral support and two instructions:

1. Find out the facts regarding cement which will be of value to the *consumer*.

2. Make no report whatsoever until the facts are conclusive.

They worked three years with the result that every cement user knows the facts today.

The cement producers had confidence in the future and confidence in their research organization—in fact, confidence in the reward of concerted, co-operative action won out for the Portland Cement Association and various other associations.

Confidence made it so.

Every consumer knows the Portland Cement Association is working to secure reduced costs and the efficient use of materials for all concerned. Who knows what future for crushed stone might be opened up by just such an expansion of knowledge of our own product?

What Can Be Expected by This Expenditure

1. Tabulate seasonal demands and educate users to rational demands with reference to distribution of unavoidable sizes in production. Provide for the distribution of crushed stone products with a minimum of conflict with the movement of other commodities in transportation.

2. Standardize consumption expectation by finding out the general connection between demand and production capacity, thus enabling both producer and consumer to figure with some certainty upon available production and market.

3. Tabulation of the uses of all crushed stone products based on the tonnage consumed.

A careful study should be made of these uses to see which ones can be extended. There would be very little justification in spending a large sum of money for research in a field which presents but little possibility of expansion.

4. Better information for the salesman regarding the value of his product, obtained through careful study of the results and statistics reported back to the company by the Research organization.

The value of the product is measured by its usefulness, and the cost of the production has little or no relation thereto.

5. Enlist services wherever possible of national, state and other agencies in every way that may assist both the producer and consumer of crushed stone products.

6. An exhaustive investigation of wasted over-production can be conducted so as to lay bare its facts in the hope of developing all possibilities of elimination.

What the Research Organization Must Not Do

1. We must not solve local problems of individual quarrymen. He will be helped to solve his own problems by the Research Bureau literature.

2. We must not make chemical or physical tests for individual quarrymen for individual or local purposes.

General information will be furnished as it is gathered with reference to the tests which a stone must meet for the various possible uses. His own analyses and tests will then show him where he stands.

3. We must not do research or laboratory work of any kind to assist an individual in a local problem.

4. We must not poach on the preserves of individual development of certain producers who prefer and have the right to the advantages of their own labors.

5. We must not become interested in selling campaigns of individual producers or products, but much valuable information can be gained from the general reports of our project, which can be used in the individual producer's selling campaigns.

6. We must not supply any member with sales argument to use on his own particular customer.

7. We must not inform customers where they may be able to get a better stone for their individual purpose.

8. We must not give any special service or advice to an individual quarryman at the expense of other member or members of the association.

9. We must never undertake to give expert advice to individuals that is not sent out to all members at the same time.

Conclusion

Obviously, this Research Bureau project must confine itself to being a clearing-house and dispenser of general information and data for use of all the members.

You men, through your instructions to the proper officials of this Association, will make rules and regulations controlling dispensing of information so as to properly protect the interests of every member of this organization.

In the Future

After the preliminary ground has been covered and we are all thoroughly informed as to what is now known regarding the various crushed stone products, we must then consider and study them and delve into the unknown. In the opinion of this committee, some of the possibilities of the near future are:

1. Development of new and varied uses of crushed stone products.

2. Keeping abreast with current affairs as they concern crushed stone operation, such as translation of technical reports; compilation of reports of various institutes and condensing the meat of them as they concern common-sense business principles, and put them in non-technical language to be clear to every one of us.

3. Assuring our entire membership of the latest developments as they occur in this and foreign countries, the same to be translated and condensed so that the non-technical man can secure all their advantages.

4. Through our Research organization we will establish recognition by the various bureaus at Washington which would be a most excellent introduction in legislative and political affairs that affect our business. This introduction, coming in this substantial way, would insure more prompt response on many other questions such as railroad matters, priorities, legislation, immigration, etc.

Finally, we urge the discussion and adoption of the six recommendations prefixed to this report, as in our opinion it is the proper way to profit by the common-sense research ideas in this Association.

N. B. Signed by the following members of the Research Committee:

Harry A. Brandon — W. K. Hoagland — Nathan C. Rockwood

Visualizing the Possibilities of Stone Quarries

By Waller Crow

Of Waller Crow, Inc., Engineers and Business Counselors, Chicago, Ill.

IN the discussion of any industry, regardless of its nature, there are a few fundamentals that must be gone into before we can discuss it intelligently. We must take into consideration what relation this industry or any other bears to the general industrial scheme, whether or not it is an industry which might be classed as parasitic or whether it is productive.

In addressing a National Crushed Stone Association, I believe I am addressing a really *productive* organization represented by a body of men who are basically producers and in every way creating something out of which a great many other industries are built. To go into the ramifications of the stone industry and the uses of stone would cause me to enumerate every article in this room, every piece of material, carpet, cloth, glass, pencils or any other possible thing that could be thought of. It would be much easier to enumerate some industry that was *not* basically derived from the stone industry, and especially limestone, than it would be to enumerate the several thousand that are.

I notice from time to time the crushed stone men will ship a carload of dolomite or high calcium stone or semi-hydraulic cement stone to remote places. It might be surprising to know just what uses this was put to; what products were brought out of it. For instance, the sugar industry cannot operate without limestone; potteries cannot operate without limestone or its derivatives; nor the glass industry would not be possible without lime in some form.

It is a mooted point now in the glass industry between the burned lime (oxide) and limestone. It takes about 6 per cent more fuel to flux the stone than the oxide. But the oxide costs much more than the relative amount of fuel to produce. This is just one point in passing that we might take into consideration and dwell on for a minute. The glass industries consume enormous quantities of limestone; the preparation varies, of course, to suit the requirements. In potteries they generally use the oxide.

We all know the ramifications of chemical limestone. In operating the ordinary quarries, very little thought has ever been given as to what that stone might really be. Limestone is limestone; where dolomite, it is dolomite. We generally class those as separate and distinct. But a limestone that may be absolutely worthless so far as indicated on the surface might be a first-class hydraulic cement rock. We are working with hydraulic cement now that has been used 85 years and the manufacturers have never lost their business and have made portland cement competitive, which indicates that every cement must not necessarily be a portland cement. The present method of manufacture of portland cement seems to be the most uneconomical and wasteful thing that can be done.

Possibilities in Natural Cements and Hydraulic Limes

Now the chances are that the majority of you gentlemen here have what you call 99

per cent limestone, high grade chemical stone or a true dolomite. But there probably are some impurities in stone which many of you use that bring it to that thin line of demarcation between a hydraulic cement and ordinary limestone. About the best hydraulic cement would run as high as 2 and 3 per cent iron, which is a little high; 7 or 8 per cent in uncombined alkali, or potash and soda; maybe 18 per cent in alumina, and 23 or 24 per cent in magnesia and residue silica. There are variations between these. There are different opinions as to what makes cementing qualities and what does not. It is not all in the colloidal form or the method in which it is prepared. A great deal is in the rock.

We find in the cementing qualities of limestone, hydraulic cements and such materials which are all classed under the same category, that in preparation there are certain points to look out for. We found through exhaustive experiments that if a certain part is converted into hydroxide and another portion into a precipitated carbonate, a combination of the two will make a strong cement on almost any material regardless of its chemical characteristics.

As to whether this is far-fetched, we need only to go back to Roman times and observe some of the works that have been built when portland cement was not known. It is true, they used volcanic ash; they also used serpentine rocks, etc., and made combinations with lime, and their works endure to this day much better than any modern cements.

I noticed in conducting some research which we undertook not so long ago, a peculiar Roman law that was to the effect that no man could, without suffering drastic penalties, manufacture lime and sell it before it had been exposed and weathered for three years. There is something in that, if we stop and look at it. In other words, we are making lime products a little too rapidly, not giving them a chemical reaction or the weathering that they must necessarily have. The chemical reactions and what they are, I don't know and never found anybody who would hazard a guess, because it is a very complicated thing when you find out what the weathering of stones or other materials actually accomplishes. But we do know that we can take weathered stone and it will make natural cement. We have observed that a pile of limestone that has weathered down is about as good cement as you want, and we must find eventually some process of bringing these materials through without destroying some of their characteristics and without hurrying them too much. We are not Romans. We can't wait three years to make lime and sell it. We haven't that time to consume and it isn't abreast of the times that we should consume that time. But there could be some process worked out from time to time and a little research done that would indicate how to accomplish that more rapidly by a little more chemical treatment and little less firing.

Byproducts of the Stone Quarry

In the production of stone, a great many of us are overlooking the fact that stone itself carries a great many byproducts. The

byproducts are not necessarily inherent in the stone but are the unsalable sizes. Take an operator in a section where he can sell all of his fines for top dressing, asphalt dressing for roads. He is all right on the fines. The other man, a hundred miles from him, can't possibly sell fines. Another man in another section can't sell very much ground limestone; which brings the whole industry back to individual units working out their own salvation. I don't believe any association which you will ever create, no matter how it is managed or how great a technical staff you have, can ever do your individual research for you. Each proposition depends so much within itself and the local conditions as to prevent any cure-all or list of fundamentals being written to apply to all general cases. One man must take his fines, get them out, store them, and eventually put them into agricultural limestone, which, by the way, is coming into its own more every day, increasing to immense tonnage. Doctor Hopkins, of the University of Illinois, tells us that we can't live without phosphate and limestone mixed. And I believe he is right. Limestone is very beneficial in most cases. The oxides and the hydrates are always necessary for quick correction. Therefore we have the possibilities of separate units for grinding unsalable sizes.

Every recommendation that we attempt to make is always based on this. Get your stone out as cheaply as possible. The only way is making a lime byproduct. I claim that burned lime is a byproduct at all times to a crushing plant whether you burn your fines in a rotary or scalp your stone and run it through a vertical kiln. Or no matter how you handle it, you have the in-between sizes for general commerce.

In taking the industry as a whole, we can talk all we want to about the making of iron and the making of steel. But if there was no limestone there would be no iron or steel. Neither would there be a great many articles which we have to use in every day living.

Financing Quarry Industries

Now in the matter of the financial aspect of the stone industry. This has never received the recognition it deserved. As I understand it, I have found in handling certain stone propositions that less is known by the general public about a stone operation than anything that you can give them; they don't comprehend it. And I think one reason is, if you will permit me to say so, that the stone man, himself, does not know enough about his proposition. He has not worked out his markets and what his stone's qualities are. Neither has he worked out the possibilities of going into the hydraulic cement business on the side. Consequently, the financial houses can not be held altogether responsible for the fact that they are not familiar with the stone industry because it has been sort of a one-man, isolated industry heretofore.

But in the next few years it can not possibly be. It is simply a case, I believe, where a man must produce stone or not produce it. And he can not make an economical operation on a capacity which does not justify the use of mechanical means. An operative man can't take a hand shovel and handle 250 tons a day and compete with a big fellow who handles direct from steam shovels into the large crushers and puts it through his bins on his cars in a continuous flow without any lost motion.

This is an industry which now is coming into its own. Its byproducts are unlimited, and it calls for much research. And I want to state again that I believe that research must be along individual lines and every man has certain problems that he must solve for himself.

This is a subject that interests me very much. I would only like to be able to present it in proportion to the interest that I have in it. I would like to talk for quite a while about dolomite, about the possibilities of certain high calcium compounds, possibilities of silicates, the possibilities of even sodium silicates, what the various acids will do and will not do, and how they will permit an operator to work out a special product for a special purpose, but that would involve considerable discussion.

There is just one thought that I want to leave and that is that we all must be sold on this basic industry for the reason that there is no industry in the United States today that is more basic in its operation or by itself controls more industries. There is hardly a chemical operation, hardly a metallurgical operation or building operation that a crushed stone man doesn't control if he will jump in and make the full utilization of it.

Action on Report of the Research Committee

MR. GRAVES: This resolution is in reference to the report of the Committee on Research, the report being presented, as you will of course remember, by Mr. Brandon. The following resolution is offered in that connection:

"Be it herewith Resolved, That the report of the Committee on Research and Extension be adopted in principle and that the Board of Directors be authorized to carry out the plan to such extent and with such modification as the board may deem wise and the funds of the association permit."

The spirit of that resolution I think is clear, that we adopt it in principle. We believe that it is along sound, progressive lines, but we feel it should be left to the Board of Directors to carry it out during the ensuing years with such modifications as they may deem wise, and, above all, with due regard to such funds as we have on hand. Nothing will be undertaken which we can not financially carry through to successful conclusion, and we offer that resolution for your consideration, and I so move you.

The motion was seconded and carried.

Tentative Outline for 1923 Research Work

THE following suggestive outline for 1923 research work was submitted to Professor Withrow at Columbus, Ohio, on January 29, 1923, by Messrs. Brandon and Rockwood on behalf of the Research Committee of the National Crushed Stone Association. This action was unofficial; and as yet (March 10) no official action has been taken by the committee or the association:

Objectives of 1923 Research Work

1. Lay foundation for a really comprehensive knowledge of the stone industry.
2. To furnish the ammunition for later publicity and promotional work.
3. To provide contributing members with real comprehensive knowledge of their own material and possible fields in which its uses may be developed, and why.

Suggestive Outline for 1923

1. To make a market survey of the limestone industry.
   (a) A list of all the industries which use limestone in any way, shape, or manner as a raw material.
   (b) The tonnages used in each such industry; tonnage produced by the industry or a subsidiary; tonnage purchased from independent producers, and physical and chemical characteristics of limestone used in the various industries.
2. Complete chemical and physical analyses of samples submitted by each of contributing members.
   (a) A complete report by code of such analyses for use of the contributing members.
   (b) A sample of each product made by contributing members and a report on the uses made of this product so far as they know, and why.
3. Summary of (1) and (2) in a comprehensive survey of the uses, kinds, and approximate tonnages of limestone used in the industries.
4. Compilation of a bibliography of the stone industry, and the sources of current literature on the subject.
5. Development of important separate themes on such general subjects as "fluxing stone," in such a manner that some conclusions could be drawn as to the dollars and cents value of certain elements or impurities. And of such a theme as the history and record of the use of limestone screenings as a fine aggregate for concrete with an accompanying bibliography that would have weight in a scientific or engineering discussion of the subject.

Trade Association Activities

By John E. MacLeish
Of Scott, Bancroft, Martin and MacLeish, Attorneys, Chicago

YOU gentlemen probably are interested in the recent decree of the district court in New York City, where an injunction was entered against the members of the Gypsum Industries Association. The decree as entered also directed and authorized certain activities by an association, thus receiving the approval of the court in affirmative form.

I have been asked to come here this afternoon and give you gentlemen a word with respect to that situation, and outline such of my experience as may be of benefit to you. I find in my work in this connection that the question is frequently asked (in fact, I noticed that it appeared on your original program) what may trade associations do? It has raised a great deal of confusion, where, in my mind, probably confusion ought not to exist. If you were to ask the question in this form, wholly aside from trade associations, what may competitors as between or among themselves do, I think you would get at the question in more direct form. And that question can better be answered by stating in the abstract what they may not do. I am limiting my discussion, of course, to the Sherman Act under the Federal laws.

It is clear that under the statute they may not make an agreement to unreasonably restrain trade or commerce, which, of course, includes all agreements to fix prices or to limit production or to divide territory or fix any other element of competition; likewise, they may not agree to monopolize any part of trade or commerce to the exclusion of other competitors. With these two things in mind, the two principal things that they may not do, it may be said that competitors, either as between two of them or among many of them, may do everything else. What two of you may do, or what a number of you may do, what two of you may discuss, or what a number of you may discuss, it follows, may be done by trade associations.

Suspicious of Trade Associations

I find, however, that the Department of Justice, in its investigation of these questions (and I am stating this upon my information gathered through many conferences with the Department of Justice) I find that many associations, so-called trade associations, have among their purposes the reporting or open-price plan. Second, the circulation of information as to production. Third, freight bureaus. Fourth, credit bureaus. Fifth, cost-accounting plans and methods, and, sixth, ethics or committees on ethics. The government's attention has been directed to these subjects because they have discovered that although most of them are quite legal as written or stated, have been used to attain illegal objects. The open-price plan—the so-called open-price plan or reporting system—is used for the purpose of fixing prices, or has been by some associations; the circulation of information as to production has been used for the purpose of limiting production, freight bureaus have been used to establish arbitrary freight rate schedules to control the delivery price and divide territory, credit bureaus have been

John E. MacLeish

used for black-listing and holding trade to the exclusion of other competitors, cost-accounting plans have been used to arbitrarily fix elements of cost, to control and maintain prices, and ethics or ethical committees have frequently been used to make definitions, rules and regulations for the purpose of enforcing these objects.

So you will not be surprised to know that the government law-enforcing officers in their investigation of this subject seem to have formed the conclusion that all trade associations are organized and maintained for illegal purposes. That is probably true because their investigations have led them to associations which have indulged in these practices. You will notice, also, that although the statement of the object, without the purpose, is perfectly legal (probably with the exception of the open-price plan of which I will speak in a minute), yet the purpose for which it is used is improper, and so when they investigate and learn that fact they become, and have become, suspicious of trade associations. As long as that suspicion remains in the Department of Justice (and that is the department you have to deal with ultimately), as long as that suspicion remains with the district attorneys, with the assistants to the Attorney General, and with the Attorney General himself, your associations will be the subject matter of investigation.

Value of Constructive Work

Associations like yours—I have glanced over your program here and find the constructive, legitimate work in which you are engaged—can do a great deal to eliminate and remove the suspicion that now lies in the mind of the government enforcing officer. That suspicion, when you get right down to it, is a belief that use is made of legitimate terms and legitimate objects, to carry on illegitimate or illegal work.

I found in our own case that it seemed an almost impossible job to convince the Department of Justice that our objects legal as stated were conducted as legal. They had this suspicion in the back of their minds and it was difficult to remove. In plain language, I laid the cards of the gypsum industry on the table of the Department of Justice. I invited the Department of Justice to investigate. I preferred, of course, an investigation by the Department of Justice itself, but it took the form of an investigation before a grand jury in New York City. That investigation was conducted over a period of 30 days or more, with the result that the grand jury refused to indict the members of the Gypsum Industries Association.

Then we worked out the theory of an equity decree with the idea of trying to build up something that would help in the furtherance of legitimate associations. The government asked that we be enjoined and restrained from doing a number of things. These things were all nothing more or less than those which are prohibited by the federal statutes, to-wit, the Sherman law. We were perfectly willing to consent to such an injunction because we were not engaged in that kind of work and because we did not intend to engage in it, and, therefore, it could do us no harm, but we requested the government in addition to that to incorporate into the decree the things

which we could do. I might call your attention to them, not that they are the limitations by any means of what an association may do; an association may do these and many things besides; but these were the things we wanted to do and by setting them up in this decree we at least drew the line between the right and the wrong; on one side of the page being the wrong and on the other side of the page being the right in so far as our association was concerned.

Legitimate Objects Defined

The decree went on to provide that we were not enjoined or restrained and that we might organize a corporation:

1. To advance or promote the use of gypsum products by research, publicity, advertisement and other activities of like character.

2. To deal with engineering and trade problems pertinent to the industry for the purpose of advancing the use of gypsum products.

3. To carry on educational work pertinent to the industry by fellowships in various schools and colleges, experimental and research work in and through institutions of learning and engineering bureaus and societies and to provide for lectures and writing and reading of papers upon subjects pertaining to the industry.

4. To maintain a traffic bureau to furnish traffic information upon specific request from published freight tariffs lawfully issued by the carriers, and to assist the industries in transportation questions before federal and state commissions and other bodies dealing with questions of transportation and with the common carriers.

5. To deal with improved methods of plant and mine operation, including sanitation, safety appliances, accident prevention, labor, plant and mine development, housing conditions, insurance and methods of accounting.

And, last, to maintain a credit bureau for the purpose of furnishing credit information.

Now you will notice that in those objects you find practically that which I listed before, but the illegal purpose is not included. It simply shows that practically all the things associations have been doing in the way of credit bureaus, in the way of freight bureaus, in the way of reports with respect to production and other objects of that kind, are perfectly legal if they are not used for an improper purpose.

Open-Price Plan Doomed

With respect to the open-price plan, I think the death knell of that plan has been written by the Supreme Court of the United States. It may possibly be that the Supreme Court, in a case where the open-price plan is brought before it, unhampered by any improper practices, would hold the plan as written legal, but the difficulty is to get such a case before the Supreme Court. One of the lawyers who had advocated that plan very strongly said to me the other day that he considered the plan legal as written, and that he thought if they could get it before the court in that form, the court would approve it. I told him that I doubted very much if he would ever find any such case and he said, "Yes, that is the difficulty with having the question decided."

The Supreme Court, with respect to that plan, said: "The plan is essentially simply an expansion of the gentlemen's agreement of former days, skilfully devised to evade the law.

"To call it open competition cannot conceal the facts that the fundamental purpose of the plan was to procure harmonious, individual action among a large number of naturally competing dealers with respect to the volume of production and prices without having any specific agreement with respect to them, and to rely for maintenance of concerted action in both respects, not upon fines and forfeitures as in earlier days, but upon what experience has shown to be the more potent and dependable restraints of business honor and social penalties cautiously reenforced by many elaborate reports which would promptly expose to his associates any disposition in any member to deviate from the tacit understanding that all were to act together"; so, I think that the open-price plan must be abandoned by associations.

Associations Must Dwell on Constructive Activities

The discussion on this subject has led to two clear-cut thoughts, or lines of opinion. One is that associations are necessary for competitors and may be operated legally. The other is that associations cannot be operated legally, are not necessary and should be wiped out. If the association worker will dwell on the constructive activities associations are gradually going into, sooner or later he would develop a force that will compel the government authorities (and I mean by that the prosecuting officers of the government) to recognize the fact that your associations are necessary and they will then receive the encouragement of the government rather than be destroyed.

I found the Department of Justice very much interested in this question and interested to the extent of wanting to assist and not to destroy. Our decree has been said to be a step forward. Some of the New York papers said it was constructive in its nature. Well, it was and it wasn't. It was a step forward in that we have at least the Department of Justice and the District Attorney putting their approval on this doctrine that associations are necessary, and have recognized the existence of one in the gypsum industry.

Reason for Incorporation

The decree, it is true, says that a corporation may be organized to carry on these activities. That question arose in this way: the government attorneys, having in mind these illegal associations, hesitated very much to permit the organization of an association among competitors. We offered to them the organization of any organization, association, corporated or unincorporated, but they preferred to use the word "corporation," and we, desiring to organize a corporation not for profit, accepted that term; but you needn't feel that by this decree associations are at all limited to the organization of corporations. You are only limited, whether in a voluntary association, in a corporation not for profit or in any other organization you may think of, to those things that are perfectly legal. And if you remove from association work the camouflage, in my judgment, you will create a force that will be of great assistance to you and to the public. If there is anything wrong in the trust laws—and I believe there is; I believe the Sherman Law is harmful to business as it is conducted today; I think the Attorney General himself probably thinks so, but the law is—it is for you gentlemen, by lawful means, to create and maintain your associations and thereby create the force which in time will cause an amendment or change in the law.

Court Decree in Gypsum Industries Case

THE complete degree of the Federal District Court in New York City, with an editorial discussion, may be found in Rock Products, January 13, 1923, pp. 33 and 43.

Association Gets a Compliment

A. E. CARROLL (Linwood Cement Co., Davenport, Iowa): Gentlemen, this is my first year to attend this convention. In fact, I am comparatively new in the stone business and not really actively engaged except as an attorney for a company and on the board of directors, but I am obliged to leave tonight and did not feel, Mr. Chairman and gentlemen, that I could go without saying just a word of my impressions of this convention.

Knowing that you were a comparatively new organization of some five years, I believe, in growth, I was indeed impressed not only with the splendid attendance, with the splendid attention you give, but with the caliber of men engaged in this industry, and yet, that is not surprising when you figure that the material that the Crushed Stone Association represents is the basic material for building foundations, roads, and it is the foundation of all this material that you must need for a basic foundation, it is not indeed surprising that this convention has gathered together such a body of men.

I have attended all of the sessions with profit and with pleasure, and I can only bespeak for your organization, if you continue as you have up to this time, the most splendid success.

Quarry Problems From the Engineer's Viewpoint

By Oliver Bowles
Mineral Technologist, U. S. Bureau of Mines

THE United States Bureau of Mines has within its ranks a group of engineers who are engaged in working out quarry problems, the solution of which will be of general benefit to the industries involved. The problems undertaken are approached in a systematic and thorough manner, all the evidence for and against any proposed change or new development being collected as carefully as an attorney would prepare his data on an important case. Unlike the attorney, however, the bureau engineer does not take sides; his judgment is based entirely and impartially on the array of facts presented.

In order to gain the desired information, he visits many plants, consults with the leaders in the industry, works out experiments in his laboratory, and supplements this information with a study of all available literature already published on the subject in any part of the world. As an engineer who has for eight years conducted such inquiries in the stone industry, I propose to discuss the Bureau of Mines viewpoint; and it may be of interest to consider with me in a brief and general way the engineer's method of looking at quarry problems, and some of the results attained through past and present labors.

While the bureau has conducted no investigation directly for the crushed stone industries, two years of investigative work at cement-plant quarries, and work now being conducted at lime-plant quarries, has a very direct bearing on the problems of the crushed-stone industry, since stripping, drilling, blasting, loading and transportation are similar in many respects in all stone quarries. The results of cement-plant quarry investigations are to be found in Bureau of Mines Bulletin No. 160[1]. Two short papers on lime-plant quarry problems have been issued in mimeographed form as Serial Nos. 2401[2] and 2424[3].

The Advantages of Trade Associations

The rapid growth of trade associations is a notable feature of present-day industry. The trade association not only promotes a spirit of fellowship, goodwill, and co-operation among the operators, but what is still more important, it affords an avenue for a more complete application of the principles of engineering to quarry practice. Many trade associations maintain research laboratories of their own, while others enlist the services of outside laboratories. Between 65 and 70 trade associations in the United States recognize the value of research sufficiently to make it an important part of their work. When research is conducted through the trade association it prevents duplication of effort in the laboratories of the different operators, and furthermore the results obtained are available to all, including the small operators who could not conduct investigational work independently.

Oliver Bowles

Dr. Bowles was born in Canada and educated at the University of Toronto, obtaining his B. A. in 1907, and M. A. in 1908. The degree of Doctor of Philosophy was conferred by George Washington University in 1922. Was in field work for the Ontario Bureau of Mines during 1908 and 1910, and instructor in petrography at University of Michigan in 1908-09. Until 1914 he lectured on rocks and minerals at the University of Minnesota, and made a comprehensive study of Minnesota quarries. The results of this work have been published as U. S. Geol. Surv. Bull. 663. Since 1914 Dr. Bowles has been stone quarry specialist in the Bureau of Mines, and has written many notable technical papers and articles. His present labors are directed chiefly toward quarrying problems in the lime industry.

You are probably aware of the fact that the Department of Commerce is giving active support to trade associations. The Bureau of Mines is also interested in the development of such organizations on the basis of their utility in the field of research. The bureau's division of mineral technology, of which I am a member, has within the past two years co-operated with the Department of Commerce in the organization of a Talc and Soapstone Producers' Association and a National Slate Association. Conflict of interest, lack of co-operation, and meager research activities were in evidence in both these industries, and it is probable that under the influence of the new associations the public will be served with better products and the operators will enjoy greater prosperity.

The Nature of Quarry Problems

Now what are some of the problems in stone quarries that the engineer may successfully undertake? The stone trades are peculiar in this respect that at the present stage of development, the main problems are not of a type that may be solved in a laboratory. My early training led me to believe that microscopes, test tubes, and chemicals were the necessary equipment for research, but a few years' work around quarries has taught me that steam shovels, scrapers and drills are the tools that must be used. By this I mean that the stone quarry itself is the laboratory, for most of the problems are of such a character that they can be worked out only in actual practice. I believe, however, that as time goes on and greater refinements are developed in quarry work, the use of precision machines in well-equipped laboratories will play a greater part in quarry research.

Examples of Bureau Problems

Some problems in the non-metallic mineral industries that we have approached in the Bureau of Mines and solved with some degree of success are as follows:

1. A determination of the relative efficiency of steam-shovel and hand-loading methods.

2. A comparison of the relative merits of cordeau and electric detonators for firing heavy blasts, indicating that the former is the more efficient.

3. A method of overcoming a condition of "strain" in marble quarries by drilling closely spaced holes, thus permitting slow expansion of the marble and avoiding heavy loses through strain fractures.

4. The development of improved grinding methods for talc and feldspar; mills recently built in accordance with bureau plans have from the start demonstrated their superiority over other types.

5. The determination by experiment that pulverized waste slate is an excellent filler for road asphalt and certain other products, thus opening a way for developing a market for a product otherwise wasted.

(1) Bowles, Oliver, "Rock Quarrying for Cement Manufacture," obtainable from the Superintendent of Documents, Washington, for 25 cents.

(2) Bowles, O., "Stripping Problems in Limestone Quarries of the Shenandoah Valley," Reports of Investigations, Bureau of Mines, October, 1922.

(3) Bowles, O., "Use of the Churn Drill at Limestone Quarries," Serial No. 2424, Reports of Investigations, Bureau of Mines, December, 1922. These serials are obtainable free, on request from the Director, Bureau of Mines, Washington.

The Engineer's Mode of Attack

Now what is the engineer's method of approach to a stone-quarry problem and what are the successive steps that must be followed in arriving at a proper solution? They may be enumerated as follows:

1. A clear idea of the exact nature of the problem.
2. Compilation of data from many plants where the processes under consideration are actually employed.
3. Review of all data already published.
4. Laboratory or industrial plant experiments if such are possible.
5. An analysis of all the facts presented.
6. A conclusion based on this analysis.
7. A verification of the conclusion.

The Slate Waste Problem as an Example

A mere enumeration of the steps followed may seem very abstract and indefinite, but I can make it clearer by referring to an actual problem. During the past three years the bureau has devoted much attention to the slate industry, the results of such studies having recently appeared as Bureau of Mines Bulletin 218, "The Technology of Slate." The outstanding problem in this industry is that of waste, for various published reports have stated that waste varies from 70 to 95 per cent of total production. Visits to the slate regions corroborated these reports, for veritable mountains of waste were found. A study of the problem indicated that two lines of investigation were open: (1) profitable utilization of waste, and (2) reduction in the proportion of waste.

In order to determine methods of utilization all literature on the subject was reviewed and co-operation was obtained from over 40 manufacturers to whom samples of pulverized slate were sent to be tested as filler in such products as asphalt and rubber. The information obtained from these tests was tabulated. The conclusion was reached that slate flour could be used successfully as a filler in rubber, linoleum, window shades, roofing mastic and particularly in road asphalt surface mixtures. It was estimated, however, that even if all uses were developed widely the actual tonnage consumed would probably utilize only a part of the available slate waste. Thus owing to the somewhat restricted uses for waste slate at the present time a second conclusion was reached, a conclusion of very great importance to slate producers, namely, that greater efforts should be expended in finding means of reducing waste than in developing ways of utilizing it.

With this conclusion in mind the second line of inquiry was followed, that of determining ways of reducing waste. A careful study was made of operating methods in nearly all active slate quarries in the United States. It was found that the proportion of waste could be materially reduced by using drills and channeling machines instead of heavy blasting, by cutting parallel with joints and ribbons, by manufacturing a greater variety of products, by making novelties from small pieces, and in other ways. By such studies at least a partial solution of the problem has been found, and a pathway has been opened for further inquiry.

The Importance of Verification

Earlier in this paper verification of the conclusion reached was mentioned as a final step taken by the engineer. Many proposed improvements will not bear the test of practical application and it is therefore a matter of vast importance to prove that any conclusion is correct. An example of such proof may be well illustrated by experiments conducted with slate flour as an asphalt filler. It was reported in an English newspaper that slate flour was the best possible filler in road asphalt surface mixtures. Some experiments in the United States verified this statement.

Now, the engineer is an inquisitive person. The trademark on every problem is a big question mark, so the question arose in my mind, "Why is this pulverized slate of excellent quality, what are the requirements of asphalt filler that the material so admirably fills?"

A study of the question revealed the fact that an asphalt filler must pack together with the smallest possible percentage of voids, for thereby low-priced filler takes the place of a large proportion of higher-priced asphalt. It also appears that a filler giving the smallest percentage of voids is one that has a very high percentage of fine material that can fill in the spaces between the larger masses.

Therefore, examination was made of samples of slate flour by a method of water suspension and decantation, and it was found that the proportion of extremely fine particles was much higher than in either pulverized limestone or portland cement. This might be called a verification in theory, for it explains theoretically why slate flour is a superior filler for asphalt. Verification in practice may be accomplished by making a piece of road using slate flour as a filler, and by finding that the road is of good quality and can be made at lower cost than when other fillers are employed.

The Engineer's Impartial Viewpoint

It is possible that many quarrymen sell pulverized limestone for road asphalt filler, and the thought may have come to them that the Bureau of Mines is in effect undermining their filler trade by urging the superior qualities of a substitute material. This brings up a very important point that I wish to emphasize. The engineer follows facts as a bloodhound follows a trail, irrespective of where they lead. The honest engineer hews to the line and lets the chips fall where they may. The quarry investigator who seeks immediate advantage with little or no regard for ultimate consequences is a mere dabbler who caters to certain interests irrespective of facts, while the honest engineer's whole purpose is to increase our knowledge of basic principles, and thus establish every advance in quarry practice on a sure, stable and unchanging foundation.

If slate flour is superior to pulverized limestone for certain uses, the slate producer is entitled to that information. It may lead to competition. In this particular case it probably will, for I find that while filler specifications prepared by the Asphalt Association formerly read "pulverized limestone or portland cement," the latest copy which I received a few days ago reads "pulverized limestone, slate flour or portland cement." The choice will be guided largely by freight rates and production costs. Thus economic relationships may shift and be thrown out of balance by new discoveries, but they gradually adjust themselves.

The important point is that bureau engineers do not put one industry ahead of another, but are impartial in their conclusions. Their purpose is to discover the truth about every quarry problem, and I am enough of an optimist to believe that the truth can work injury to no one, and conversely that every advance in process based on fact raises the standard of all mining or quarrying industries to a higher level.

The Operator Should Apply Engineering Principles

During recent years I have visited about 600 stone quarries. Many of them are highly efficient operations, but, on the other hand, I find some processes in use that are as crude as those employed in Egypt when the pyramids were built. The employment of inefficient methods is due partly to lack of capital, partly to tradition or to the influence of methods used in surrounding operations, and partly to unusual quarry conditions, but one great outstanding lack is the failure to apply the principles of engineering to the problems encountered. Some problems may require the experience and knowledge of a trained engineer, and he should be called in consultation. In many instances, however, the operator is quite capable of solving his own problems by applying to them two important engineering principles.

The first principle is the ability to see both sides of a question to weigh the evidence impartially, and to dismiss from consideration any preconceived opinion as to the most desirable solution of the problem. The second important principle is the establishment of conclusions on a sound basis of fact. Thus the preparation of positive data is a necessary function of any investigator, and this can be done only by keeping exact records of tonnage and costs. Few economic problems can be solved without using figures, and no quarryman can hope to solve his problems without the aid of systematic records. Many processes now in use would be abandoned tomorrow if the operator had before him on a sheet of paper a set of figures indicating their excessive cost.

At a convention of this character, a great

array of facts is presented, and discussion by operators of widely varying experience makes it possible to view each question from many different angles. Undoubtedly the greatest benefit may be derived from the facts and expressions of opinion brought to your notice if the watchword of our proceeding is the first engineering principle, "*Judgment without partiality.*"

Hydraulic Stripping of Quarry Overburden

By Victor J. Milkowski

Engineer in Charge of Dredging Department, Morris Machine Works, Baldwinsville, N. Y.

THE subject of hydraulic stripping can best be introduced by comparing it to the flushing of a pavement or deck by means of a hose. The overburden in this case can be considered as represented by the dirt, while the ledge or the deposit that it is desired to uncover can be considered to be represented by the pavement or deck.

In Fig. 1 you have the whole story condensed and simplified and portrayed for ideal conditions. At the left we show the face of the overburden to be removed. The overburden is washed down by the monitor or hydraulic giant and is sluiced into a sump, shown under the tripod. From there the mixture of material and water is pumped across the stream to an enclosed area to the right, where the solid material settles and the water is returned into the stream through a spillway.

The smaller pump shown in the foreground supplies water to the monitor, while the larger pump, shown in the center, is the sand and dredging pump that delivers the material to the spoil areas. Both of the pumps are shown directly connected to motors. Unless the stream is very large, the pressure pump supplying water to the monitor must be placed above the spillway from the spoil area in order to have clear water.

As stated in the beginning, the conditions pictured here are ideal; which conditions, of course, seldom exist in actual practice; however, the general principles shown here apply in any case, with the possible exception that where there is ample elevation the dredging pump can be dispensed with, and the material and water can be sluiced direct to the spoil area without the aid of the dredging pump.

Must Have Favorable Conditions

To install this hydraulic method of stripping, it is necessary to have the following conditions:

1. Suitable material.
2. Large volume of material to be moved.
3. Suitable underlying strata or deposit.
4. Ample water supply.
5. Suitable space for the disposal of spoil.
6. Ample and cheap power.

Considering the foregoing in detail, it is obvious that hydraulic stripping can only be employed successfully where the overburden is comparatively soft and is free from large boulders. That does not preclude, however, occasional boulders or streaks of hard clay and compacted material, which can be broken up with sufficient pressure behind the nozzle.

The second requirement—that is, a large volume of material to be moved—is simply a case of unit cost. While the equipment required for this method is not very costly or elaborate, it is highly specialized and requires special organization and special methods. For these reasons, hydraulic stripping can only be employed economically on a large scale.

The third requirement—that is, suitable underlying strata—is of importance, as these strata form the working floor of the pit. It is desirable that this floor be impervious, flat and preferably sloping away from the working face. A very porous or irregular

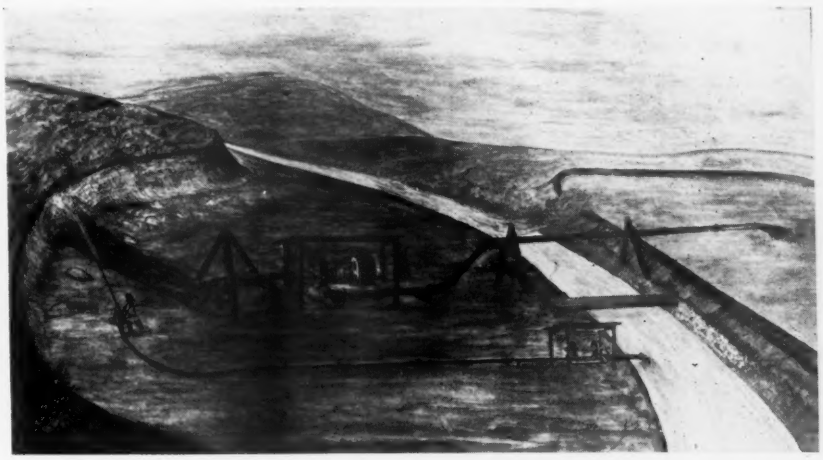


Fig. 1—Sketch showing ideal arrangement of hydraulic stripping operation

Fig. 2—Typical stripping operation in Florida phosphate field

Fig. 3—Florida phosphate operations on a large scale

Fig. 4—Stripping iron-ore deposits in Minnesota by hydraulic methods

floor might make hydraulic stripping impractical.

Under the fourth requirement—that is, ample water supply—it is necessary to bear in mind that ordinarily this method requires the handling of about ten volumes of water to one volume of solid material. It is possible, of course, to utilize the same water over and over again if suitable sedimentation basins can be provided to permit the water to become clarified.

The fifth condition—that is, suitable spoil areas—is of importance, as the material and water must be delivered into suitable area enclosed with dykes, where the solid matter can settle to the bottom and the waste water can drain off. This, in some cases, is a very small problem, while in other cases the difficulties may be insurmountable.

Under the sixth requirement mentioned—that is, ample and cheap power—it is necessary to remember that the pumping of such large volumes of water mixed with material requires the expenditure of considerable power, especially where it is necessary to pump through long pipe lines and against high lifts. For this reason, the hydraulic method of stripping can only be employed successfully in places where power can be developed at reasonable cost. Electric current is by far the best for this purpose, as it is necessary to move the equipment frequently, especially the dredging pump.

Examples of Hydraulic Stripping

The best examples of hydraulic stripping and mining in this country are in the Florida phosphate fields and in the iron ore regions of Minnesota. In the former case, the phosphate-bearing material is about 20 ft. in depth and is overlaid by about 20 ft. of overburden, consisting of a conglomerate mixture of sand, clay, etc.

Fig. 2 shows a typical stripping operation in Florida. The monitors are supplied with water from a central pumping station about a mile distant. The dredging pump shown in the center is directly connected to a motor, and discharges the material about 1000 ft. away and about 40 ft. above the level of the pump.

Fig. 3 shows the operations in Florida on a somewhat wider scale. The pump to the left is employed in the mining of the material; the operation of mining being exactly the same as stripping except that in mining, the material is pumped to a recovery plant, where the phosphate is separated from the

Fig. 5—Another view of Minnesota iron-range stripping

Fig. 6—A discharge line, Minnesota iron-mine stripping

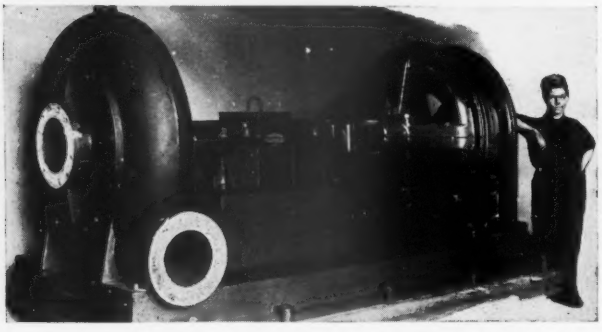


Fig. 7—Pump and motor used for hydraulic monitor in stripping operations

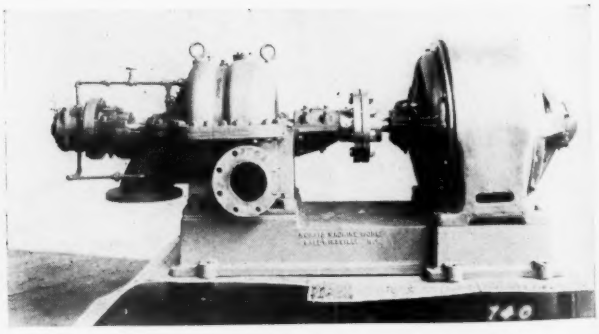


Fig. 8—Dredging pump, commonly employed for the disposal of the overburden in hydraulic stripping operations

debris. The end of the suction pipe is immediately in front of the group of men in the center. One monitor, breaking down the material, can be seen in the extreme right of the picture. In the upper right-hand corner there is shown another pump which was used for stripping. The bank beyond this pump shows the stripping face, while the bank in front shows the mining face.

The stripping operations in Minnesota are probably of greater interest on account of the large volume of material handled and on account of the low unit cost. The overburden in this case consisted of about 50 ft. of conglomerate material underlaid with about 2 ft. of hardpan on top of the ore.

Fig. 4 is a view of typical stripping operations in Minnesota. The vertical pipe in the foreground is the dredging pump suction, while the pipe to the right is the dredging pump discharge. To the left can be seen the monitor breaking down and sluicing the material to the dredging pump suction. Water was supplied to the monitor in this case from a point about half a mile distant, while the waste material was discharged through 900 to 1500 ft. of pipe with a lift of about 27 ft.

Fig. 5 is another view of the operations in Minnesota. The housing of the dredging pump can be seen in the lower left-hand corner, while the monitor can be seen a little above the center to the right.

Exact unit costs were kept on one of the stripping operations in Minnesota, and these were found in 1914 to be between 5½ and 7 cents per cu. yd., including all overhead. The material was moved on the average about 1300 ft. with a lift of 27 ft.

Fig. 6 shows a typical scene at the end of the discharge pipe; the pipe in this case being 12-in. This brings out clearly the importance of having suitable spoil areas for the discharge.

Fig. 7 is a view of the pump and motor used for supplying water to the monitors on one stripping operation, while Fig. 8 shows a 12-in. dredging pump and motor commonly used for the disposal of the solid material.

The aim of the foregoing discussion and illustrations is to bring out only the general characteristics of this method, as each particular case presents a special and an individual problem with its own particular solution. Wherever the conditions are correct for the application of this method, no other method can compare with it in economy. On the whole, it can be stated that the power costs with this method are relatively high, while the labor cost and the cost of the upkeep of the equipment are reduced to a minimum. For these reasons the hydraulic method is recognized as being the best for excavating and moving large volumes of earth or other loose materials, such as in stripping the overburden in a quarry as considered in the present case.

Stripping Clay from Seams and Pockets in the Shenandoah Valley in Virginia

By Dr. Oliver Bowles

DURING the past summer my attention has been directed toward the problem of removing overburden from uneven rock surfaces, deep pockets and seams. This is a problem that relates particularly to limestone producers, but may be of interest to any quarryman who is confronted with a difficult stripping operation.

Ordinary mechanical means of removal are inadequate on very rough surfaces, and in consequence stripping may be a very slow and costly process. The development of efficient methods of stripping under such adverse conditions is a problem of very great importance to many quarry operators.

Two general methods are followed in removing the clay. The greater part of it may be stripped back before the ledge is blasted down, or clay and rock may be shot down together and separated later at the quarry floor. The first method is usually followed where a foot or more of solid clay lies above the highest points of rock. Where numerous knobs or ridges of rock are exposed at the surface, the difficulty of digging the clay from between the rock masses commonly results in the quarryman's following the second method—that of blasting down rock and clay together, and separating them while loading.

Where a large volume of clay occurs free enough from rock masses to permit the use of such mechanical equipment as the steam shovel or dragline scraper, it is undoubtedly wiser to remove as much as possible of the clay before blasting down the rock. If the rock surface is so extremely rugged that it is advisable to use hand tools only, the relative merits of the two methods are more difficult to judge. If rock and clay are shot down together, the intimate mixture makes separation slow and difficult.

In rainy weather the clay adheres to the rock fragments and the quarrying of clean rock becomes impossible. On the other hand, in cleaning out the pockets before blasting, the clay is fairly free of loose rock, fragments, and the rock subsequently shot down is clean in either wet or dry weather. In loading dirt at the quarry floor, however, the laborer is required to lift it only high enough to clear the edge of the quarry car; in cleaning out pockets from the surface, clay must sometimes be raised 10 to 20 ft. Loading in the quarry is also much more rapid as the clay is loose, whereas the firm, undisturbed clay in the pockets may require excessive use of the pick, or may even require blasting; thus its removal is slow and expensive.

High Cost of Hand Loading

Hand loading of clay is laborious, slow, and costly. This fact is recognized by most quarry operators, but owing to adverse conditions the method is still widely used. The cost of loading dirt by hand at the quarry floor in 1922 varied from 15 to 25 cents per cubic yard. Hand loading of clay at the surface varied from 30 to 45 cents a yard. The latter figure applies to direct loading of clay from the bank to the car or dump cart. The cost may be very much higher where the clay is removed from deep cavities. At one quarry observed four men shoveled the same masses of clay to successively higher benches, and a fifth man loaded it into a dump cart. Under such conditions the cost might reach $1 or $1.50 per yard. Owing to the excessive cost of hand loading, operators are urged to employ mechanical means wherever possible. Now, what are some of the ways in which this type of stripping may be accomplished mechanically? The hydraulic method, which will be discussed by an able authority, is sometimes applicable and is very desirable wherever conditions are favorable for its employment.

Dragline Excavator

A dragline excavator operated from a derrick arm has been used successfully in cleaning out clay pockets in Pennsylvania. The entire equipment is on a portable mounting, and the excavated material is loaded on cars just as when a steam shovel is employed. It cleans out shallow depressions fairly well, but some hand work is required in the deeper cavities. The lateral motion of the derrick arm gives the excavator a wide range and great flexibility of movement.

Dragline Scraper

The simple form of dragline scraper may be used where a convenient dumping ground is available. Though some convenient devices for shifting the sheave attachment have been devised, in general this scraper lacks flexibility in lateral motion.

Clamshell Bucket

A clamshell bucket operated from a derrick arm or crane has been used to a limited extent in moving soil overburden. In the opinion of some operators this is the best equipment for cleaning out large cavities.

Tractor Excavator

A small tractor excavator, widely used in road grading, has been employed with success on eroded limestone surfaces in

Pennsylvania. The dipper slides back and forth on an arm 12 or 14 ft. in length, which may be raised and swung aside for dumping into cars or wagons. The excavator is so equipped that the dipper may be lowered into a pit, loading as it is elevated toward the surface. Such an adaptation permits it to be used in cleaning out clay pockets.

Steam Shovel for Soil Only

The steam shovel is sometimes used on very rough surfaces. Rock projections so interfere with continuous operation that great patience is required, and the operator must be prepared for much lost time both in loading and in moving. The shovel will not excavate from deep pockets, hence much hand work must follow, but where a depth of several feet of clay is encountered, the steam shovel is much more economical than hand loading. The smaller types of tractor, or caterpillar shovels with dippers not more than ¾ yd. in size, are best adapted for such work.

According to report, a method that has been used in Pennsylvania involves the use of the steam shovel for removal of both rock and clay in the upper part of the deposit. The great bulk of the clay in pockets and seams is usually confined to the upper 6 to 12 ft. of the limestone deposit; thus if a cut 6 to 12 ft. deep is made, the clay may be loaded into cars with a small tractor shovel having a ½- or ¾-yd. dipper, and the rock masses drilled and blasted as they are encountered.

The rock thus obtained may be loaded into separate cars, but it is not deemed advisable to do so, for it is difficult if not impossible to load clean rock with a steam shovel where rock and soil are mixed. A better method is to make a shovel cut at the edge of the quarry pit, loading the clay into cars and throwing all the rock masses encountered over the edge of the pit where they may subsequently be loaded at the quarry floor. By such means a fairly clean separation of rock and soil is accomplished.

Most of the methods already mentioned relate to operations of limited size, or to quarries where the rock is loaded by hand as at many small- or medium-sized plants. For crushed stone operations which are usually conducted on a fairly large scale a washing and screening plant in conjunction with a steam shovel is probably the most efficient means of handling clay in pockets. Where several feet of clay lies above the uneven surface a steam shovel may be used to remove the overburden down to the level of the upper rock projections. All the clay below this level may then be shot down with the rock, loaded with the rock, passed through the crusher and separated by washing. If the clay is not lumpy a fair separation may be accomplished in dry weather by screening alone, but to obtain clean rock in any weather a washer is essential.

Removal of Clay from Deep and Extensive Erosion Cavities

Occasionally clay-filled cavities of large size are encountered. In one quarry in Virginia a mass of clay 60 ft. across reached to the bottom of an 80-ft. excavation. On account of the slow hand methods employed, its removal seriously curtailed the output of the plant for two years. Obviously it would have been easy for a steam shovel, operating on the quarry floor, to remove such a mass in a few weeks.

Deep erosion cavities often occur in places where it is difficult or impossible to employ ordinary mechanical methods of removal. Several instances have been observed where a succession of laborers shovel the clay from bench to bench until it is finally thrown to a point from which it can be loaded into cars or dump carts. Such methods date back to antiquity, and involve a labor charge that is prohibitive under modern wage conditions. If a clamshell bucket, dragline excavator, or similar device cannot be employed, it is suggested that the soil be mechanically elevated by means of some type of wagon-loading equipment now so generally used. A portable belt or bucket elevator is easily placed in position, and may be operated at low cost by electric motor or gasoline engine. With such simple equipment two men could easily do the work of six or seven.

Discussion on Hydraulic Stripping

By J. J. Sloan

I HAVE not done very much hydraulic stripping. Thirty years ago in Idaho I did a lot of placer mining, including stripping, but where you have an empire to work in there is not much risk or damage to your neighbors and you do not have to figure losses. This kind of a proposition is not comparable to hydraulic stripping in gravel pits or quarries at the present time.

In the quartzite district of South Dakota I tried to strip a 6-ft. burden, largely of black loam, but as we got into it we found it heavily packed with glacial boulders running from 50 to 1200 lb. We used a three-phase pump throwing 850 gal. per minute with 200-lb. nozzle pressure with a 2-in. giant, but due to an uneven bedrock with pinnacles and depressions it was a rank failure, and cost a matter of 45 cents per cubic yard in place to move it.

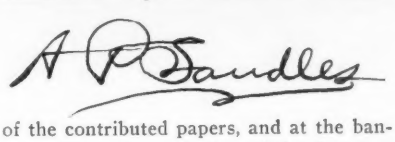
Recently in the Wisconsin limestone district we used a small three-phase pump with 150 lb. pressure and a 2 in. nozzle with less than 2 ft. of black loam, but what we overlooked was a selvage of 6 in. of clay next to the bedrock. We tried to cut this later in small chunks and float it off, as it was impossible of washing, but it could not be done. As a result we had to go in and take it up by hand method and strip it.

With a 60-ton steam shovel and three locomotives handling 6-yd. cars, we moved stripping of from 6 to 8 ft. of black dirt off a certain proposition a distance of 1800 to 2500 ft. with a daily expense of about $75, moving in round figures 2000 cu. yd. of loose material a day, so that its cost was about 4 cents per cubic yard, loose measurement. This is the best record we have been able to obtain.

The ordinary winters do not interfere with such stripping operations, and most plants aim to keep certain help steady the year round, and winter stripping affords work for them. There is no outfit that I know of that will do ordinary stripping as cheaply and as effectively as your own shovel, cars and locomotives. Only a few things are needed, and as the ordinary plant is thus equipped, you will find that, utilizing your own equipment and keeping your organization intact, it is as cheap a way to do this work as it can humanly be done.

The Secretary of the National Crushed Stone Association

A. P. SANDLES' name does not occur in these transactions as a participant, but his well-known oratorical powers were used to good advantage in reading some



of the contributed papers, and at the banquet. With the exception of the first two or three months of its life, Mr. Sandles has nursed the National Crushed Stone Association from its cradle to its present splendid development.—The Editor.

Scientific Quarry Blasting

By J. Barab
Hercules Powder Co.

DURING the last 10 years blasting practice among quarrymen has greatly improved. You are all familiar with the greater efficiency, economy, and safety which have resulted from the increasing use of well-drilled holes certain high cartridge-count special ammonium nitrate dynamites and Cordeau-Bickford.

I shall speak briefly of this; but if we wish to use explosive forces to the best advantage we ought to know something about the way these forces act; therefore, before going into any of the details of quarry blasting I am going to take a little of your time to explain the theory of explosions, and to present diagrams which may give some of you a clearer idea of what takes place during the blast.

An explosive reaction is the rapid transformation of the explosive, which may be solid, liquid, or a mixture of substances, into other more stable substances—largely or entirely gaseous—of much greater volume. Such a reaction produces intense heat. This is a very general definition, and it also accords with the definition of combustion; because an explosive reaction is always a form of combustion. It is the rapid expansion of gases into a volume very much larger than the original substance which causes destruction or accomplishes useful work.

Contrary to beliefs that are still widely held among blasters, the force of an explosion is exerted equally in all directions. This may be demonstrated by confining an explosive in the center of a sphere.

Fig. 1 represents the effect when water is so confined and is heated until the pressure is sufficient to burst the sphere. This is what happens when a steam boiler explodes.

Fig. 2 represents the effect when an explosive such as black powder is set off in a sphere, and Fig. 3 illustrates the same thing with a high explosive like dynamite.

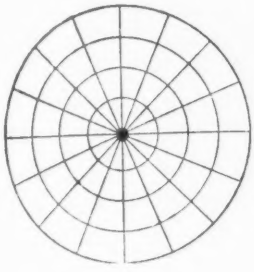


Fig. 1

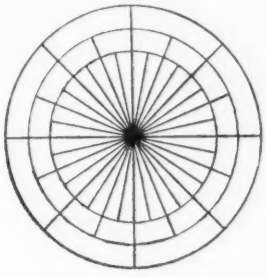


Fig. 2

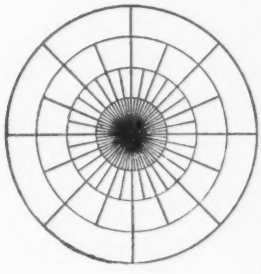


Fig. 3

The lines radiating from the center in these diagrams represent the forces which result from an explosion. It will be noted that in Fig. 1 all lines go to the outer surface of the sphere; in Fig. 2 only a portion reach the surface, and a still smaller portion in Fig. 3, where there is a marked concentration of lines immediately around the explosive.

The greatest effect on the surrounding material will be produced where the lines have the highest concentration. These three figures clearly show the difference in shattering effect between a low order of explosion like that produced by steam, and a high order such as is produced by dynamite. This demonstrates why it is that black powder has a less shattering effect and more of a spreading effect than dynamite.

Fig. 4-A shows a section of a bank in which pocket loading was used, and the bank is so proportioned that if properly loaded no "toe," or hard bottom, will remain after the shot.

Fig. 4-B indicates the useful action that would occur if the resistance were equal on all sides of the explosion. Forces equal to those indicated by the lines in the segment shown would be working in the other segments, but would not contribute toward breaking down the bank. But in quarry shooting the resistances are very much greater below the explosive and on the side away from the face, and therefore the action that takes place is not as is shown in Fig. 4-B, but is similar to that shown in Fig. 6-A. The forces that are liberated follow the lines of least resistance.

When a hole is drilled so that the charge is located, as shown in Fig. 5, the "toe" being too great for a satisfactory shot, hard bottom will remain, because in following the lines of least resistance the forces will expend themselves without breaking the "toe" to the bottom.

Figs. 6-A, 7-A, and 6-B and 7-B illustrate the difference in the action produced by explosives in pocket loading and in column loading. We have seen that the greatest shattering action is always in the vicinity of the charge. In pocket loading Figs. 6-A and 6-B, this is at the bottom of the hole; whereas, in column loading, Figs. 7-A and 7-B, as the charge is distributed throughout the length of the hole, the shattering action is distributed over greater area.

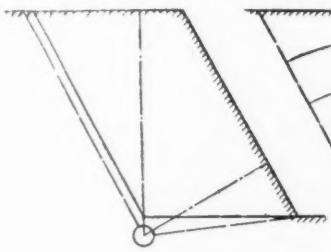


Fig. 4-A

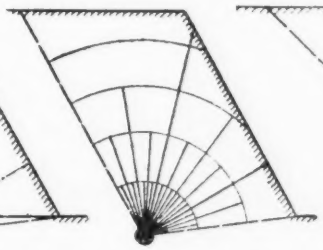


Fig. 4-B

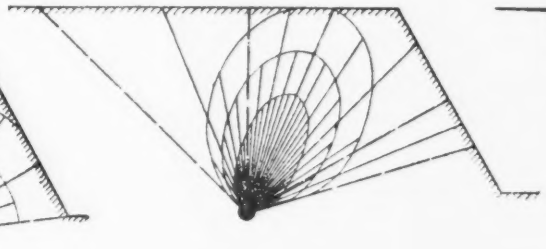


Fig. 5

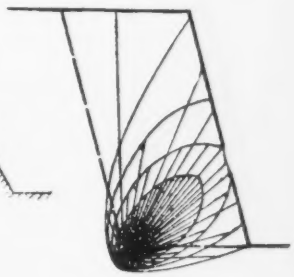


Fig. 6-A

Pocket loading, whether in machine or well-drilled holes, or tunnels, is most satisfactory in rock that will break small enough by the force of its fall. Rock that is too hard for this requires the direct action of explosives to break it sufficiently, and in such material, column loading should give best results.

Special Blasting Methods

Practically all grades of explosives have

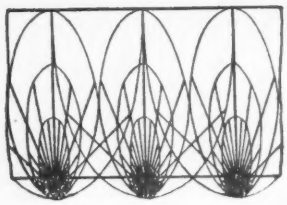


Fig. 6-B

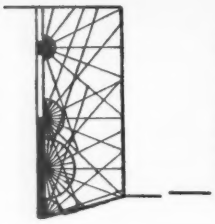


Fig. 7-A

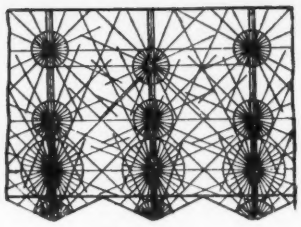


Fig. 7-B

been used at one time or another in quarry blasting. The explosive first used was black blasting powder, and it is still used to some extent. If it will do the work, it is the most economical explosive to use. However, most of the improvements of the last 10 years have been accomplished with other

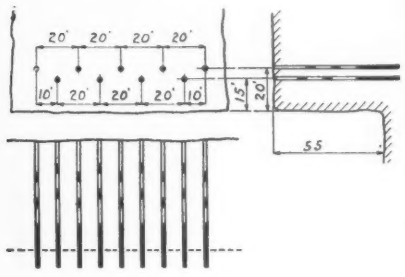


Fig. 8

explosives. During this period well-drilling has become an established method in many parts of the country.

Costs have been brought down rapidly by column loading in well-drilled holes with certain special high cartridge-count ammonium nitrate dynamites. These special dynamites have proved more effective than the high-velocity explosives which they have often replaced, because their velocity is less and their action is not so shattering in the immediate vicinity of the charge. These dynamites are about midway between black powder and high-grade nitroglycerin dynamites both in velocity and strength. Also, they are cheaper. They cost about the same per 100 lb. as 40 per cent extra; they can usually be shot, cartridge for cartridge, with the 40 per cent, but as there are about one-third more cartridges in a case, their economy is self-evident.

In deep well-drilled holes electric shot-

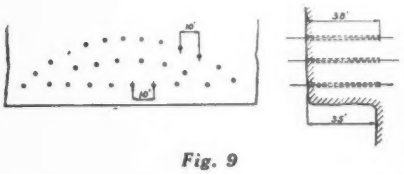


Fig. 9

firing has been largely displaced by Cordeau-Bickford, which is a small lead tube filled with T. N. T. Its rate of detonation is about 17,000 ft. per second, and by using this throughout the entire length of the drill hole a higher velocity is imparted to the explosive used, if its rate of detonation is less than that of the Cordeau. Besides increasing the rate of detonation, Cordeau insures complete detonation throughout the length of the charge.

Conservatively estimated, Cordeau increases the efficiency of an explosive at least 10 per cent and this increase will usually more than pay for the Cordeau. It has another important advantage in its safety. It is the only high explosive which can be regularly shipped by express under the I. C. C. regulations.

In addition to providing increased safety and efficiency, Cordeau also decreases the amount of time and labor in connecting up a shot. To make the connections for a large number of holes, when firing with electric blasting caps, takes considerably more time than is required with Cordeau. Each electric blasting cap and all connections should be tested with a galvanometer to be sure

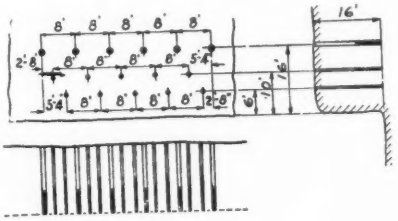


Fig. 10

there are no breaks in the circuit and great care has to be exercised to avoid wrong connections.

Where more than one electric blasting cap is used in a hole, which is necessary with deck-loading, and advisable in column loading, the cost for time and labor and the chances of making mistakes are decreased proportionately with Cordeau. Connecting all holes to the trunk lines is comparatively simple and takes only a fraction of the time required for electrical connections. When Cordeau is used, there is no necessity for a blasting cap on the job until just before firing.

I believe this makes quite clear the reasons why these comparatively new methods have lowered costs, and I think that any of you who have not considered one or all of them as a possible means of increasing efficiency should do so. The details of their application under usual conditions need not be discussed before an assembly of this kind; but most work is not so simple that we can deal constantly with ordinary conditions.

I have run across some quarry-blasting problems that are somewhat out of the ordinary, which I shall present to you with diagrams showing how they were successfully solved. In doing this it is not my thought that many of you will have exactly similar conditions to contend with, or that you can solve your unusual problems in exactly the same way, but because I believe they may prove suggestive, and that your own ingenuity will devise modifications which will adapt them to your work.

At a large silica sandstone quarry it was found that, when the holes were drilled in a straight line, the rock was ordinarily brought down in large sizes. Apparently in this rock the explosive expended most of its energy in shearing the rock from the face without sufficient shattering effect. This difficulty was, to a great degree, overcome by staggering the single row of holes to make a zigzag row, as shown in Fig. 8.

At another quarry great difficulty was encountered in breaking the rock on the bottom, where it appeared to be harder than any other place. By drilling the holes, as shown in Fig. 9, most of this trouble was overcome.

At still another quarry in hard limestone, better results were obtained by the system of drilling illustrated in Fig. 10. The rows of holes farthest from the face were put down with well drills and the charge concentrated near the bottom of the hole. Two rows of holes in front of this were tripod drilled and loaded so that the explosive came from half-way up to within 5 ft. of the surface. This method of drilling and loading greatly reduced secondary blasting.

At a Northern Ohio limestone quarry in hard, stratified limestone it was found that when using ordinary drilling and loading methods much of the rock was not broken up into sizes convenient for handling. The system shown in Fig. 11 was adopted to overcome this. The holes in the back row were drilled 60 ft. deep, and those in front

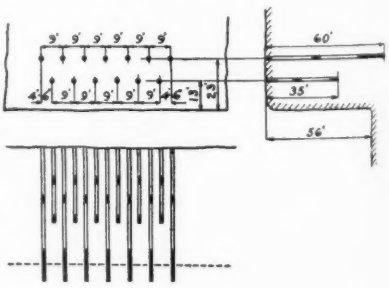


Fig. 11

only 35 ft. The charge in the deep holes consisted of 150 lb. of 40 per cent straight nitroglycerin dynamite and 40 per cent gelatin. The front holes were loaded with 50 lb. of 40 per cent straight nitroglycerin dyna-

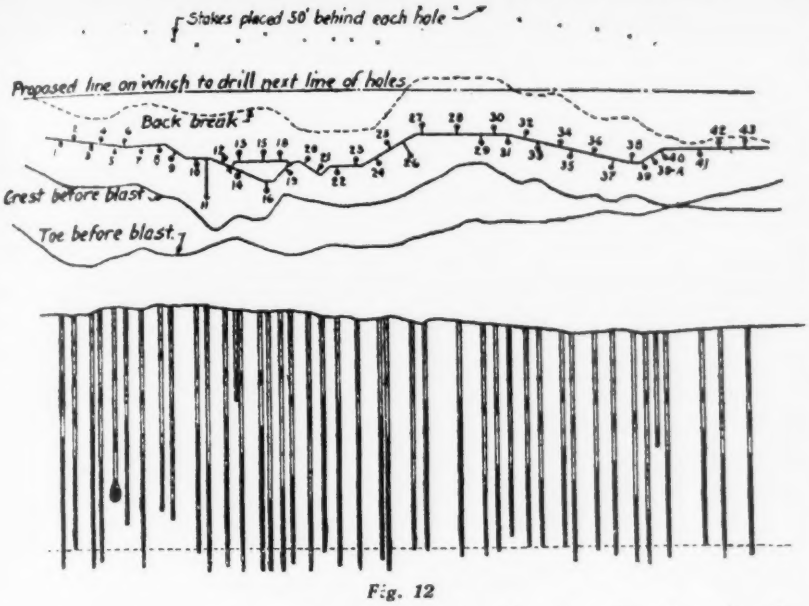

Stakes placed 50' behind each hole
Proposed line on which to drill next line of holes
Back break
Crest before blast
Toe before blast

Fig. 12

mite. The charges were spaced as shown in the diagram. After this method was adopted the proportion of large sizes was considerably reduced.

When the quarry bank is ragged, such as that shown in Fig. 12, the average cut which the steam shovel can take is lessened and the cost of production proportionately increased.

A straight bank, which permits the steam shovel to operate at uniform speed, is therefore a great advantage. In the blast illustrated in Fig. 12, insufficient holes had been

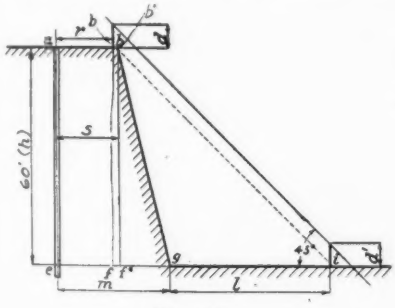


Fig. 13

drilled at the start and the holes were poorly spaced. Additional holes had to be drilled to insure a satisfactory shot. Even with these additional holes, however, a very ragged bank resulted, as is shown by the dotted line which indicates the back-break. Before the blast was fired, stakes were placed 50 ft. behind each hole from which measurements were made to lay out the next row of holes in a straight line, as shown in the diagram. By straightening the quarry face in this manner, production can be increased and a lower cost per ton obtained.

Measurements, Calculations and Records

I wish to speak of something that is too much neglected by nearly all users of explosives—the matter of controlling expense by making preliminary measurements and calculations and by keeping records. Many quarrymen, who are greatly concerned over every penny lost in paying a workman for overtime he did not put in, are oblivious to dollars lost through operating inefficiency, merely because the latter is less tangible. A mistake in timekeeping involving a dollar or two is considered serious, while a mistake in estimating the charge required for a deep well hole, which may increase the cost of production hundreds of dollars, due to the difficult digging it leaves for the steam shovel, is often overlooked. Heavy losses due to poor methods are frequently classed as unavoidable burdens or necessary working expense; but a careful record system of each operation should reveal these losses and indicate how to avoid them.

It should be obvious to anyone that no matter how sound in theory our methods may be, in a practical matter involving so many variations in the material blasted

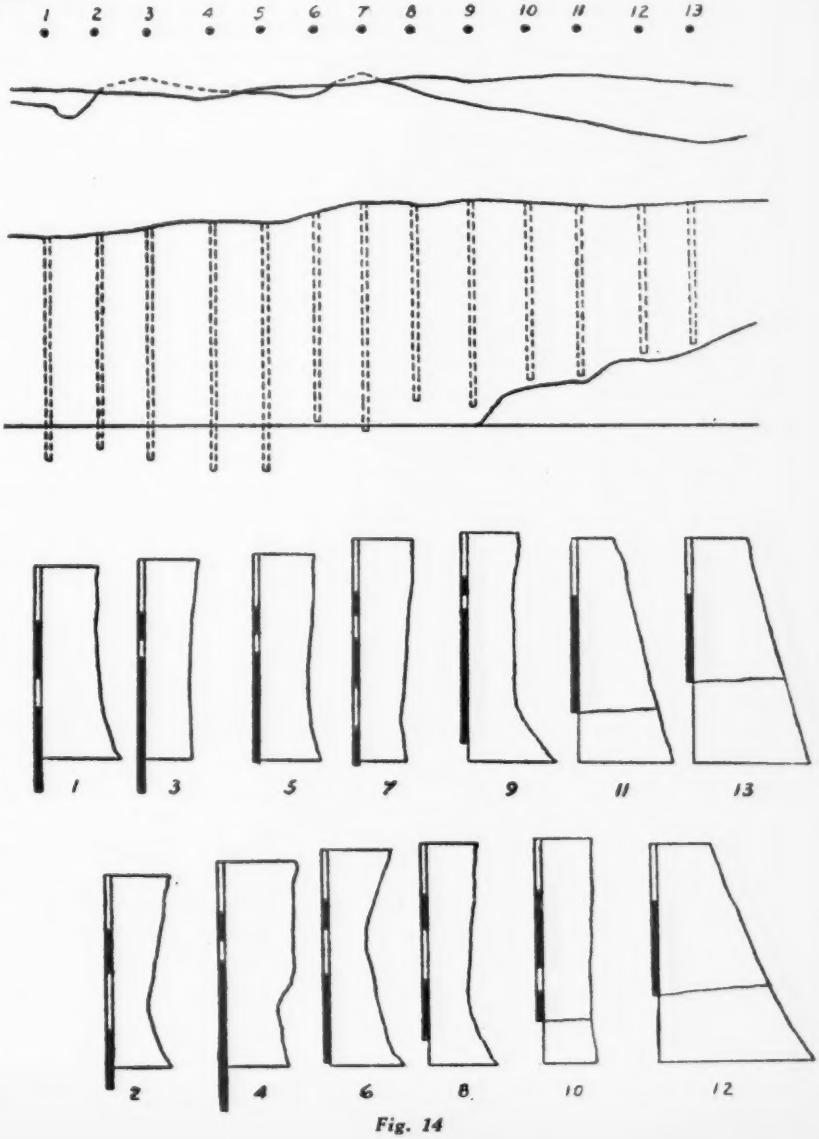


Fig. 14

and the conditions under which it is blasted, and so many opportunities for human error, we shall never be able to apply our knowledge to the best advantage unless we take steps to correlate and record all these diverse factors as they occur in our work.

There are quarrymen who can, by looking at a hole, estimate closely the correct amount of explosives to use. It has been our experience, however, that in many instances serious errors are made by the best judges. Careful measurements should be made for all blasts, and the quantity and distribution of explosives should be accurately calculated before a pound of powder is loaded. This work may seem burdensome to those who are not accustomed to it, but it will more than pay for itself by obviating mistakes in judgment that would otherwise not be discovered until the steam shovel encounters hard digging.

Experience is our best guide in determining the amount of powder which will be required per ton of rock. Once this is settled, the measurements necessary for calculating the burden or tonnage on each hole should be made. If there is an engineer on the job he can make a survey before the blast. Failing this, however, the following simple method will give results that closely approximate engineers' measurements.

The calculations for finding the burden at the toe are illustrated in Fig. 13. The height of the bank can usually be ascertained by throwing over a line—and the distance between holes is readily found with a tape. The distance d is the height of the observer's eye from the ground; r is the distance from the hole to the point at which the observer stands when taking measurements. With a hand level, set at 45 deg., a sight is taken down to the quarry floor to a rod on which a point has been marked a distance from the ground—d', equal to d. A stake is dropped on the quarry floor at the point determined by this 45 deg. line. The distance from the stake to the toe is measured with a tape—it is shown in Fig. 13 as l.

In the right triangle bfi, with its hypotenuse at 45 deg., the leg, bf, is equal to fi. The burden on the toe of the hole, m, equals $fi+ef-l$. But $fi=fb=h$, *and* $ef=r$. Therefore, $m=h+r-l$.

As an example of how to calculate the proper explosive charge, let us assume a problem where h, the height of the bank, is 60 ft.; r, the distance of the observer from the hole, is 12 ft.; s, the distance from the top of the hole to the rim, is 18 ft.; and l, the distance from the rod to the toe of the quarry, is 40 ft. Also assume that the distance of this hole from the adjoining holes on either side of it is 15 ft.; that the rock weighs 160 lb. per cu. ft.; and that 1 lb. of explosive should be figured on for each 4 tons of rock.

From the formula developed, m, the burden on the hole at the toe equals $h+r-l$, or 60+12—40, which is 32 ft. The area $ab'ef'$ equals $18\times60=1080$ sq. ft. Area $b'f'g$ equals $(32-18)\div2\times60=420$ sq. ft. The total area $ab'ge$ equals 420+1080=1500 sq. ft. This multiplied by 15 ft., the linear distance along the face that this hole should break, equals a total burden on the hole of 22,500 cu. ft. This multiplied by 160 equals 3,600,000 lb., or 1800 tons of rock. Dividing 1800 tons by 4, the proper proportion of loading known from experience, gives 450 lb. as the proper explosive charge for this hole. The correct charge for each hole should be calculated in this manner before a pound of powder is loaded.

Not only are better results obtained with less cost when the explosive charge for each hole is carefully calculated, but quite often considerable damage may be done unless this practice is followed. Fig. 14 illustrates a shot which might have serious consequences had not the charge in each hole been figured very carefully. It will be seen from the diagrams of the cross sections taken at each hole that the bank was very irregular; in some places there was a considerable overhang at the top and at other holes an unusually heavy toe. If the explosive charges in holes 2, 7, and 8, for example, had not been broken at the point near the bottom where the bank sloped in toward the hole, rocks might have been thrown far enough to damage the crusher and boiler house and

DETAILED LOADING SHEET USED AT OPEN-PIT MINE IN ARIZONA

Hole No.	Ht. of Bank	Depth Hole	Bottom		Deck Loading				Stemming Ft.	Total Lbs. Explosives
			Lbs.	Depth	Lbs.	Depth	Lbs.	Depth		
1										
2										
3										
4										
17										
18										
19										
20										

COST DATA AT A WESTERN OPERATION.

COST	Labor	Material	Other Expenses	Tota
Drilling	$6343.35	$5234.32	$1119.81	$12,697.48
Loading & refilling	2466.24	51.59	415.59	2,935.42
Explosives		13392.80		13,392.80
Total	8811.59	18678.71	1535.40	29,025.70

UNIT COSTS

1449 Feet	Per linear foot penetration			
Drilling	$4.378	$3.612	$.773	$8.763
Loading & refilling	1.703	036	.287	2.026
Total	6.081	3.648	1.060	10.789

250,000 cu. yds.	Per cubic yard of rock			
Drilling	.0254	$.0209	$.0045	$.0508
Loading & refilling	.0098	.0002	.0017	.0117
Explosives		0536		.0536
Total	.0352	.0747	.0062	.1161

One large blast consisted of shooting the face of a hill 1000 feet long with an average height of about 70 feet. The explosives were loaded in tunnels drilled at 60 ft. intervals at right angles to the face. Eleven tunnels were driven 3′ x 4′ in cross section and 60 ft. in length, with a 40 ft. T at the end, each T containing two circular pockets 5′ x 5′ sunk slightly below the floor level. The drilling was done by air-driven jack hammers.

The labor turnover was extremely high and during the very hot weather was approximately 100% per day. This of course made all labor items rather high.

Black Blasting Powder was the principal blasting charge. Three No. 7 Electric Blasting Caps and 150 lbs. 40% Dynamite were used as a primer for each pocket. The detonators were connected in parallel and fired from a 440 volt circuit.

dwellings, some of which were within 300 ft. of the face. However, by calculating the burden on each hole and placing the charges in the holes so that they were not concentrated at the places where the bank sloped inward, none of the rock was thrown more than 150 ft. from the face.

Record Systems

Many quarries have adopted record systems. The ideal record is one that will give all the information needed with the least effort. After studying a number of the forms in use, we have prepared several types which should assist in analyzing blasting costs and in keeping them at a minimum. Some variations in the forms may be necessary to fit local conditions, but we believe these are good types to follow.

Conclusions

I have briefly covered the theory of explosions, touched upon the more important recent advances in blasting practice, described a number of special blasting methods which have solved unusual problems, and outlined methods of making measurements and calculations and of keeping records. Experience has proved that this information is of practical value. Present conditions demand from those in charge of quarry work a scientific application of just such knowledge as this. If any member of this association wishes to discuss other blasting problems I shall be glad to hear from him either at this meeting or through correspondence.

The following general data and tables may be helpful in your work

OPEN-PIT MINE IN ARIZONA

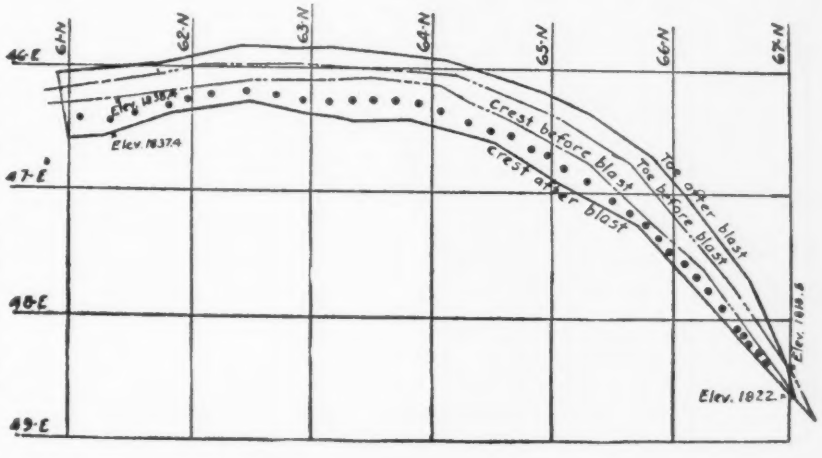
Detailed Cost of Drilling and Blasting—36 Tripod Drill Holes—Second Cut Hill No. 1—Ore Broken, 32,700 Tons; 6.17 Tons Per Lb. Explosives

Item	Quantity	Price	Cost	Cost per ton
Labor—				
Drilling			$376.40	$.0115
Springing & Loading			157.28	.0048
Supplies—				
Drilling			188.20	.0058
Explosives—				
Springing	1162 lbs.	$.1910	221.94	.0068
Loading	307 lbs.	.1960	60.17	
	4973 lbs.	.1910	949.84	.0309
Exploders & Blast. Wire			36.30	.0011
Total			1990.13	.0609

GOOD PROPORTIONS FOR MEDIUM HARD ROCK FOR POCKET LOADING

Height of Bank	Depth of Hole	Max Toe.
20	22	16
25	28	20
30	33	22-25
35	39	20-30
40	45	25-32
45	50	25-35
50	55	30-40
60	66	35-45
75	82	45
90	98	45
100	108	45-50

Where the back-break is unusually large you can look with suspicion on the success of the blast, for very likely a hard toe has been left.



Suggested Spacing of Well-Drill Holes on Faces of Different Heights in Various Kinds of Material

Kind of Material		Granite Gneiss Quartzite	Hard Solid and Thickly Bedded Limestone and Dolomite	Medium Thickly Stratafied Limestone	Thinly Laminated Limestone	Sandstone	Shale Medium Hard to Soft
CLASS OF EXPLOSIVE For Average Conditions		I	II	III	IV	V	VI
Spacing in Feet for Given Depth of Cut Feet	15	7x8	8x9	9x10	10x12	9x10	10x12
	20	9x11	10x12	10x12	12x14	10x12	12x15
	25	10x12	10x12	12x14	12x14	12x14	15x18
	30	12x14	12x15	12x15	12x16	13x15	15x18
	35	12x14	12x15	14x16	12x16	14x17	16x18
	40	12x14	12x16	14x18	14x18	14x18	17x21
	45	13x15	12x16	14x19	14x20	15x18	18x22
	50	14x15	14x17	14x20	14x20	15x20	19x24
	55	14x16	14x18	15x21	15x22	16x20	19x24
	60	14x16	15x20	15x22	16x25	16x22	20x26
	70	15x18	16x20	16x23	16x26	20x24	22x27
	80	16x20	18x22	16x25	18x28	18x25	20x28
	90	16x21	18x22	18x26	18x29	18x25	20x29
	100	16x22	18x24	20x28	20x30	20x30	20x30
	120	16x25	20x25	20x29	20x30	20x30	20x32

Class I. 60% Gelatin Dynamite. If very wet or extremely hard rock. 60% Straight L. F. N. G. Dynamite. 60% Extra L. F. or Ammonia Dynamite.

Class II. 60% Grade as in Class I in bottom of hole, and Special No. 1 in remainder of hole.

Class III. 40%—60% Dynamite in bottom and Special No. 1 on top.

Class IV. If work is fairly dry—Special No. 1.
If work is wet or a heavy toe is present, 40% should be used in bottom—remainder Special No. 1.

Class V. If dry, Special No. 1. Sandstone, however, varies so greatly in character and conditions that even a 60% Gelatin may at times be used to advantage.

Class VI. Special No. 2, unless extremely wet work is encountered when Gelatin or other water resistant powder should be used in bottom of hole.

Trap rock is usually given under the first column, but we have found that trap rock formations vary greatly.

Number Cubic Yards of Material in the Solid Displaced per Foot of Hole at Different Spacings For Vertical Faces.

DISTANCE HOLES ARE SPACED APART IN FEET

DISTANCE HOLES ARE SET BACK FROM FACE IN FEET	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
7	1.81	2.0	2.33	2.7	2.85	3.11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	2.0	2.37	2.65	2.96	3.26	3.55	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9	2.33	2.65	3.0	3.33	3.66	4.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10	2.7	2.96	3.33	3.7	4.1	4.44	4.81	5.18	5.55	5.92	....	....	....	....	....	....	....	....	....	....	....	....	....	....
11	....	3.26	3.66	4.1	4.48	4.88	5.3	5.7	6.11	6.52	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	....	....	4.0	4.44	4.88	5.33	5.77	6.22	6.66	7.11	7.55	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	4.81	5.3	5.77	6.26	6.74	7.22	7.70	8.18	....	....	....	....	....	....	....	....	....	....	....	....	....
14	....	....	....	5.18	5.7	6.22	6.74	7.26	7.77	8.30	8.81	9.33	9.85	10.37	....	....	....	....	....	....	....	....	....	....
15	....	....	....	5.55	6.11	6.66	7.22	7.77	8.33	8.88	9.44	10.0	10.55	11.11	11.66	12.22	12.78	13.33	13.88	14.44	15.0	15.55	16.1	16.66
16	....	....	....	....	....	7.11	7.70	8.30	8.88	9.48	10.07	10.66	11.8	11.85	12.44	13.03	13.63	14.22	14.81	15.74	16.45	16.60	17.18	17.77
17	....	....	....	....	....	7.55	8.18	8.81	9.44	10.07	10.70	11.33	11.96	12.59	13.22	13.85	14.48	15.11	15.74	16.37	17.0	17.63	18.26	18.88
18	....	....	....	....	....	8.0	8.66	9.33	10.0	10.66	11.33	12.0	12.66	13.33	14.37	14.66	15.33	16.0	16.66	17.33	18.0	18.52	19	19.33
19	....	....	....	....	....	....	9.15	9.85	10.55	11.3	11.96	12.66	13.37	14.07	14.77	15.43	16.18	16.88	17.60	18.30	19.0	19.70	20.40	21.11
20	....	....	....	....	....	....	9.63	10.37	11.11	11.85	12.59	13.33	14.07	14.81	15.55	16.30	17.03	17.77	18.51	19.26	20.0	20.74	21.48	22.22
21	....	....	....	....	....	....	....	....	11.66	12.44	13.22	14.37	14.77	15.55	16.33	17.11	17.88	18.66	19.44	20.22	21.0	21.77	22.55	23.33
22	....	....	....	....	....	....	....	....	12.22	13.03	13.85	14.66	15.48	16.30	17.11	17.92	18.74	19.55	20.4	21.18	22.0	22.88	23.63	24.44
23	....	....	....	....	....	....	....	....	12.78	13.63	14.48	15.33	16.18	17.03	17.88	18.74	19.59	20.44	21.39	22.14	23.0	23.85	24.7	25.55
24	....	....	....	....	....	....	....	....	13.33	14.22	15.11	16.0	16.88	17.77	18.66	19.55	20.44	21.33	22.22	23.11	24.0	24.88	25.77	26.66
25	....	....	....	....	....	....	....	....	13.88	14.81	15.74	16.66	17.60	18.51	19.44	20.4	21.39	22.22	23.14	24.07	25.0	25.92	26.88	27.77
26	....	....	....	....	....	....	....	....	14.44	15.74	16.37	17.33	18.30	19.26	20.22	21.18	22.14	23.11	24.07	24.66	26.0	26.96	27.92	28.88
27	....	....	....	....	....	....	....	....	15.0	16.00	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0
28	....	....	....	....	....	....	....	....	15.55	16.60	17.63	18.52	19.70	20.74	21.77	22.83	23.85	24.88	25.92	26.96	28.0	29.03	30.81	31.11
29	....	....	....	....	....	....	....	....	16.1	17.18	18.26	19.33	20.40	21.48	22.55	23.63	24.7	25.77	26.88	27.92	29.0	30.07	31.14	32.22
30	....	....	....	....	....	....	....	....	16.66	17.77	18.88	20.0	21.11	22.22	23.33	24.44	25.55	26.66	27.77	28.88	30.0	31.11	32.22	33.33
31	....	....	....	....	....	....	....	....	....	....	....	....	....	....	23.74	25.26	26.4	27.55	28.7	29.85	31.0	32.14	33.29	34.44
32	....	....	....	....	....	....	....	....	....	....	....	....	....	....	24.88	26.74	27.59	28.44	29.63	30.81	32.0	33.18	34.37	35.55
33	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	28.26	29.33	30.55	31.77	33.0	34.22	35.44	36.66
34	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	31.48	32.74	34.0	35.25	36.51	37.77
35	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32.4	33.7	35.0	36.29	37.59	38.88

TO CONVERT TO TONS

- For Limestone, multiply by 2.27
- For Trap Rock, multiply by 2.52
- For Granite, multiply by 2.8
- For Shale, multiply by 2.18
- For Sandstone, multiply by 1.84

DEPTH OF WELL-DRILL HOLES WITH COLUMN LOADING FOR VARIOUS HEIGHTS OF BANK, WHERE NATURAL PARTING PLANES ARE NOT PRESENT AT FLOOR LEVEL

Height of Bank	Depth of Hole	Height of Bank	Depth of Hole
	Depth of Holes		
15	17	50	55
20	22	55	60
25	28	60	65
30	33	65	70
35	38	80	86
40	44	90	96
45	49	100	106
		120	127

Discussion of Drilling and Blasting

By Alexander McKernan

Superintendent, New Haven Trap Rock Co., New Haven, Conn.

THE following is the operating practice in a modern stone-crushing plant which crushes trap rock for commercial purposes —a stone that will pass through a 2½-in. ring and downward. Our plant has an output of 600,000 tons in an operating year of nine months:

Stripping

The overburden in this quarry is comparatively light, and is removed by means of a small revolving steam shovel, together with teams and men.

Drilling and Blasting

We use well drills for vertical holes and

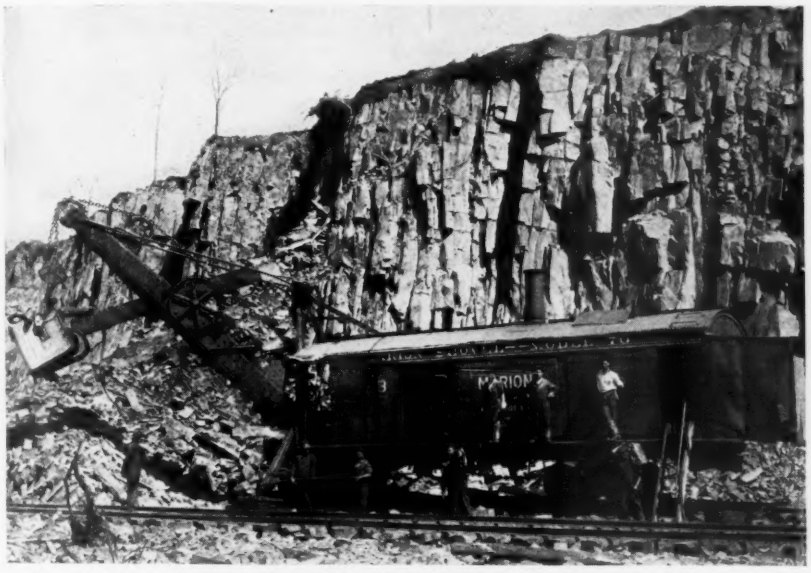
Loading the snake holes preparatory to blasting

The result of the blast

steam drills for horizontal or snake-holes. We endeavor to maintain a quarry face not exceeding 60 ft. in height, to facilitate handling the stone with steam shovels and thus avoid slides and overhangs.

Vertical well-drill holes 8 in. in diameter, spaced 20 ft. apart are drilled, 30 ft. back of the quarry face, to a depth of 40 ft. (about two-thirds of the height of the face).

Horizontal or snake-holes are drilled at the quarry floor 7 ft. apart to a depth of 28 ft. These holes are finished approximately 4 ft. below the level of quarry floor to avoid high places being left after the shot that would obstruct the free movement of steam shovels and to obviate the necessity of a secondary shot. These holes are sprung to form a pocket in the bottom of the hole to receive the charge of dynamite.



Loading trap rock for delivery to the crusher

The effect of the shot through the vertical holes serves to relieve the weight on the bottom holes and also breaks down the top of the quarry face.

We find that the best results are obtained by double-loading these holes—that is, placing part of the charge at the bottom, the remainder being placed 20 ft. from the top, using tamping between the two charges. Two detonators are used in each charge, all wires leading to the surface. The remainder of the hole is filled with tamping. All detonators are connected up with lead wires and fired simultaneously.

Loading Horizontal or Snake Holes

We use long pointed loading sticks, placing the cartridge on the end of the stick, passing it to the bottom of the hole, and repeating the operation until the necessary amount of dynamite has been placed. We use two detonators, one at the bottom and one near the top of the charge. The object of using two detonators is to avoid the possibility of a misfire.

All stone is loaded by steam shovels in 6-yd. side-dump cars and delivered to the crusher over standard-gage railroad and hauled by steam locomotives. The contents of each car (about 10 tons) is dumped directly into our initial crusher.

Crushers

Our initial or primary crusher is of the jaw type and 48x72 in. The entire product from the primary crushers is passed directly into the secondary crusher, which is of the gyratory type. The product is then conveyed to a scalping screen, the residue from which is conveyed to a battery of five gyratory crushers.

The product from these crushers is passed through two screens 60 in. in diameter, where stone of commercial sizes is screened out; the residue passes directly into two disc crushers. This product is again screened and the rejections are returned to the disc crushers for final disposition.

Screening

The entire product from the crusher house is conveyed by belt up to the screen house to an elevation of 90 ft., where the five different sizes are screened out and fall into separate bins.

Loading Stone from Screen House

We load by gravity from the bins directly into railroad cars, the stone being delivered directly to the railroad siding or dumped in bins at our dock for water shipment.

When the demand for certain sizes is not equal to our output, we dump on a ground storage where a locomotive crane disposes of it as necessity requires.

Extracts from Judson C. King's Talk at the Agstone Luncheon

THE Agstone people who form this group are perhaps as progressive, if not more so, than some of the other groups that might be assembled in the other rooms. We have all gathered here for the express purpose of talking about the product in which we are interested, and listening to those people who come here prepared to make speeches. This group is especially interested in agricultural limestone, a product which heretofore, I say that advisedly, has been considered a by-product. We now believe we are able and willing to take this product out of the infant class and place it on its own feet.

Those of us who have been working especially in the agricultural limestone game for the past several years, believe that it is not any more in the infant class, and that while we have spent large sums of money for the education of the farmer and have co-operated with the Farm Bureaus, with the Soils Departments of the various universities and have together educated the farmer intensively in certain sections to the use of ground limestone, which we term agricultural limestone, believe that it has progressed to a certain point or to such a point that from now on it will not be in the infant class again.

We believe we have taken this infant, nursed it tenderly as a mother would nurse a child, and we have now placed it upon its own feet so that it will begin from now on to make profit.

I say that I do not believe that any of us who has heretofore been manufacturing or producing agricultural limestone can boast of any profit we might have made from this material, but we believe that after all these years of effort the time has come when we are entitled at least to a small margin of profit, and, from now on we are going to work to that end.

The National Agricultural Limestone Association has done more to take this industry out of the infant class than any other thing I can think of. We have met together on the first Thursday of every month in Cleveland and we have discussed not only our problems but the problems of others and have endeavored to interest them so that they can be interested in our association and the work that we are doing.

The prices which we are able to obtain for our material have always been tabooed in our meetings. That is a subject we have never discussed, and yet automatically through the co-operation of all of these different people and sensing the necessity of placing the material upon the basis upon which we can make a small margin of profit, that price has increased to a point where we are now satisfied that we can lay aside a certain sum each year for promotional purposes, and yet not come out at the small end of the horn.

Blasting in Cities

By Otho M. Graves
Assistant to President, General Crushed Stone Co., Easton, Pa.

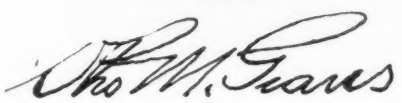
IN June of 1919, the General Crushed Stone Co. took over a property at Winchester, a trap rock quarry, getting out perhaps 1000 to 1200 tons a day on a fair average, with a face about 800 ft. long and about 140 ft. high at the center, sloping down on the two wings. The nearest houses to it are about 1500 ft. away, and we own all the land around the quarry up to these houses. There are some several hundred of these houses. We looked the quarry over very carefully, naturally, before we undertook to operate it, though we gave but little thought to the possibility of damage by blasting, because it seemed so utterly preposterous that the shooting could possibly damage any houses there.

Complaints began to come in almost immediately after we started operating in June. They were largely, however, to the effect that the damage in the houses about which complaint was made was due to the operation of our predecessors. We didn't know, of course, how our predecessors had operated: we didn't think they had done any damage as we looked about the houses, but we were quite well aware of the fact that in the first place we couldn't prove that no damage had been done, if it should go to law; and, also, we were not unmindful that we were strangers in that community, viewed with that suspicion and scepticism that may, unfortunately, at times, extend to foreign corporations. We had some desire to show these people about us that we were quite willing to meet them half way, that we wouldn't split hairs on any small adjustment, and, therefore, we began to fix these different things that were called to our attention, which averaged in financial damage to from $50 to $250 or $300 a house. The more, however, that we looked into it (and, of course, we would examine every house about which complaint was made), the more convinced we became that we were not doing any damage, and we then began to give some serious attention to having a seismological expert come in and determine for our own benefit whether or not the vibration set up by our well-drill blasting was sufficient to damage these houses in the manner claimed.

Experts Called On

We found that there were two portable seismographs for recording seismologic vibration in existence, one of which is owned and operated by Professor Hall of the University of California, and the other by Mr. Maurice Deutsch, of New York City.

We, therefore, appealed to Mr. Deutsch and to Professor E. H. Rockwell, an eminent consulting engineer of Boston, now Dean of Engineering of Rutgers College, to investigate for us that question and to report to us exactly their findings, and not to try to convince themselves or to convince us that the vibration was not sufficient to do damage, if they thought it was, but to tell us what conditions actually existed. They



did this, beginning in May of 1920 and extending through 1920 and most of 1921.

Use of a Seismograph to Determine Effect of Blasting

The seismograph I won't go into detail to describe further than to say that it records on a rotating drum by means of lever arms ending in needles which trace curves on smoked paper on the revolving drum in front. These curves show to what extent a building vibrates horizontally east and west and north and south, and at right angles to it, in a vertical direction.

Still avoiding detail, which is the trap into which I am liable to fall at any time, knowing the amplitude of the vibration wave, which is merely just like a wave on the water, and the frequency with which these waves of vibration come, it can be computed what the acceleration is with which they travel, which is the evaluation of the effective force brought to bear by the vibration waves.

There may be one major curve showing the vibration set np by a blast, but when that blast went off, possibly a truck may have been passing by. That superimposes on that major curve another little curve following the major curve but showing another source of vibration, and superimposed again on that may be a third vibration curve because somebody may have walked upstairs and that is caught, so that it isn't impossible, although somewhat difficult, to trace four distinct waves all following their major and secondary curves and showing four sources of vibration occurring all at the same time.

Now these machines are very sensitive; for instance, a seismograph at Harvard University (that is a permanent one) records the surf pounding on the north shore seven miles away from Cambridge.

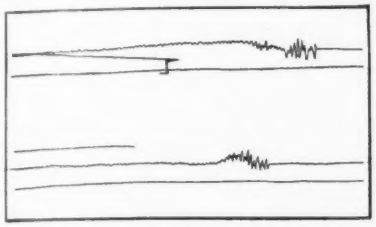
Stop Paying Damages

We got these records in houses near our quarry and they so clearly showed by the wave curve that the amplitude was so low, being about at a maximum of one-hundredth of an inch (that is the total, both up and down, not in any case in excess of one-hundredth of an inch), and the frequency so low, about ten per second, that the resultant acceleration was not sufficient to damage structures of any kind. Now when we came to this conclusion, which was not so much our conclusion as that of our experts, with whom we worked as closely as we could, we stopped paying any damages. We said to complaining property owners, "We are sorry if you think we did this, but we think we didn't," and we explained to them what we had accomplished, and endeavored to convince each individual who came to us, in as courteous a manner as possible, without getting on any high horse about it, that we didn't think we were doing any damage.

Now in the meantime, we had paid some $8000 or $10,000 in damages in the way I indicated, and when we stopped paying, all those who hadn't been paid anything went right up in the air. They said, "You paid them, why don't you pay us?" It didn't seem to be a question as to whether there was any inherent reason why we should pay, but merely, "You paid him, why shouldn't you pay me? I think as much of the company as he does," and all that sort of stuff. But we simply sat quiet and said, "No, we have nothing further to say," and the agitation gradually died down.

We thought we were out of the woods and going on a straight and narrow path, but in October of 1921 a suit was brought. I doubt if the total amount of the damage

in the house was over a few hundred dollars, but it seemed to us that since it was the first case in over two years it was just as well to defend it. We had all the data we needed and if the courts felt we were doing any damage, that was a good time to find



Vibrations caused by a blast (one-half actual record)

it out. If not, then we would be very glad to have a clean bill of health.

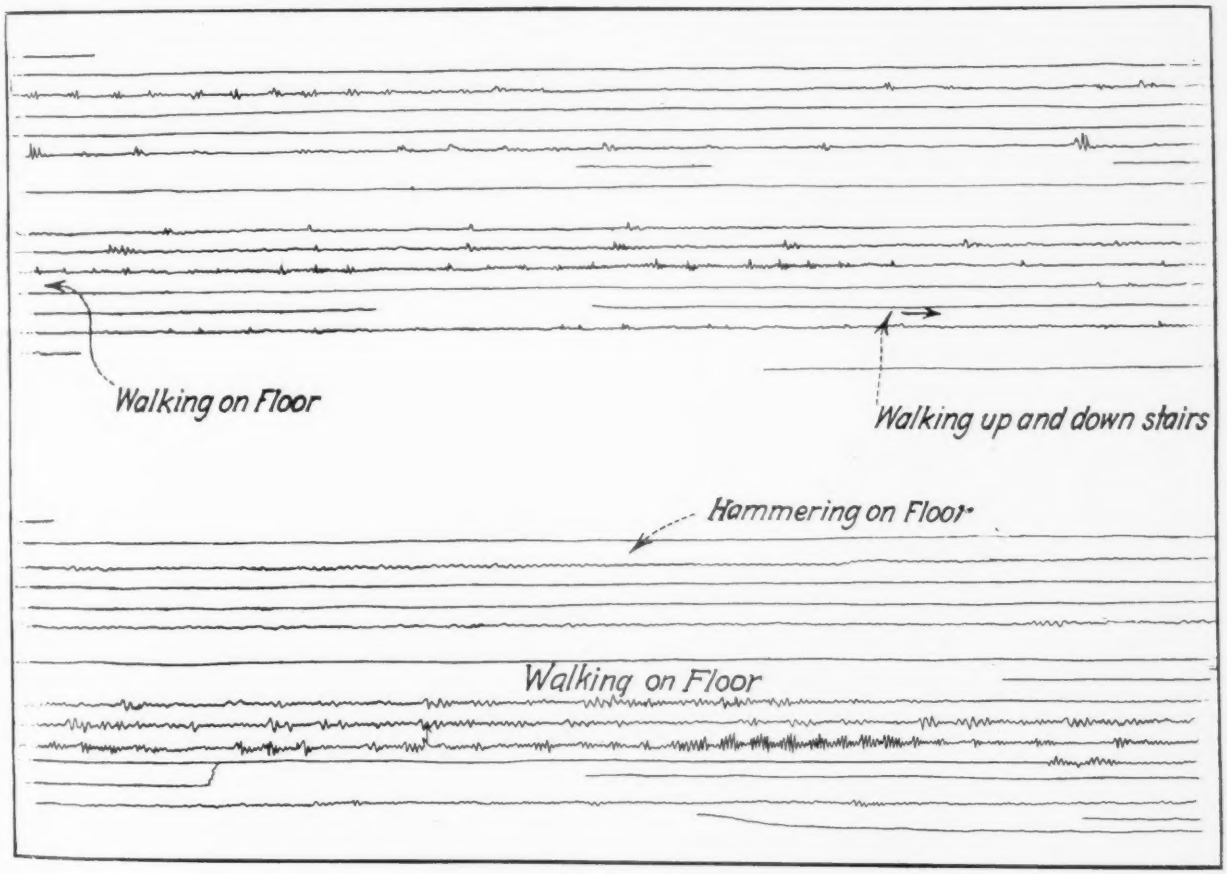
Case Brought to Court

We expected the trial would last two or three weeks at the most. It started in early December, 1921, and it has been in session practically every week, with such postponements as might naturally be expected for one reason or other; that is some 15 or 16 months. As a matter of fact, all the evidence is in and we are only now preparing the brief which is to be written or printed, and if any of you are interested in that sort of thing, I shall be very glad, on application from you, to see that you are supplied with it. It has really been, I think, the most exhaustive study that has ever been undertaken to accurately and scientifically determine the amount of vibration set up by well-drill shots in so far as the effect is concerned on structures of all sorts.

The testimony of the plaintiff has been in general along the lines of bringing in dozens of adjacent neighbors (and not necessarily adjacent, going to a distance of three miles to get them) to say how their houses had been damaged. It is easy enough to stand up and recite the condition of a house and say, "Why the ceiling in the bathroom is cracked and there is a crack down the wall of the dining room and the pantry is all cracked to pieces," and all that. It is difficult, however, for them to directly connect that condition with the blasting operation, although the continued pouring in of that testimony, "My house is like this and my house is like that and the foundation wall is cracked," and all that, does build up, I think, at least a presumption that something of all this may have been due to a similar cause in all cases, and the only common cause would be the blasting operation. Then they introduced some expert testimony of a relatively negative nature.

The type of our defense has been in the first place to show that the condition of these houses, which were brought in as inferential evidence, could not be so construed, and to take up each one of those houses as a separate case and show that it wasn't the blasting that did the damage in the case of that particular house; it was the settlement of the northeast corner of the foundation or some similar entirely local cause.

There were a very few claims as specific as that a blast went off and a window was broken. Before this suit started, by the way, a woman complained that a blast had broken the window of a house. I went over and found a hole about 6 or 9 in. in diameter. From the way it was broken, I could not conceive that it had been caused by earth vibration or air concussion. I was looking around when I saw a baseball lying on the opposite side of the room. I said, "Where are the children, Mrs. So-and-So?" She said, "I haven't any children." I said, "Do



Seismograph record showing vibrations of a building (one-half actual record)

you and your husband play baseball in your parlor?"

"No."

"I noticed a ball over there which was the reason I asked."

She said, "Well, you need not say anything more about the window, I guess that is all right."

I could tell you dozens of those instances and could go into more length than that; and the final ending, like a story of O. Henry, works out very unexpectedly in some of those incidents.

Expert Testimony to Disprove Alleged Blasting Damage

Coming back to the case we endeavored to show that the conditions in these houses, which were brought in as inferential evidence, were not due to blasting or any one common cause but were due to settlement, weathering, wear and tear, shrinkage and natural causes of that sort; and we didn't do that in any offhand, haphazard manner. We had as an expert witness a building contractor in Boston, a man with an established reputation; he has been a mayor of Summerville and built a large section of the suburbs there. He examined each of these houses. We also had them examined by two civil engineers of standing and by Mr. Deutsch, who is a building expert, and by Professor Reid of Johns-Hopkins University, who is unquestionably the foremost seismologist in the world; his reputation in those lines is international in the broadest sense of the term.

Our experts went over all these houses. We clearly showed what had caused the damage. And in the next division of our defense, we showed (or endeavored in so far as we could show) that the blasting set up vibrations of characteristics insufficient to cause the damage claimed. We showed that through the seismological testimony.

The plaintiff then introduced certain expert testimony, notably that of Professor Woodworth, of Harvard, who is a geologist and seismologist. His testimony did not particularly strengthen their case, as it seemed to us to fail to in any way connect the conditions complained of in the plaintiff's house with our blasting operations. Mr. Moore, consulting engineer, of Boston, also testified to a considerable extent for the plaintiff, but his conclusion was entirely negative, inasmuch as he stated that in his opinion the blasting was responsible for the conditions in the house merely because he was unable to find any other cause.

In the next place we showed that those vibrations couldn't have done it, by introducing engineering testimony to show that if the acceleration was so much reaching this house, it was the equivalent of so much force and that that force was insufficient to bring the various building materials to a point of rupture; that in some cases the force set up only one one-hundredth of the stresses and strains which each of these materials could safely stand.

In addition to having fairly clearly shown that, in the first place, we could not have caused the damage complained of and, in the next place, showing that we did not cause it, we endeavored to make clear what was the actual cause of the cracked plaster and stucco, which were the principal elements of complaint. We believe that we have clearly shown that certain shrinkage within the house was the cause of this condition, but I will not go into further detail as to our contention in this regard, inasmuch as the argument has not yet been made before the court. It is our belief that the difficulty which confronted the plaintiff of endeavoring to connect our blasting operation with the conditions in the house of which he complained proved an insurmountable obstacle, and this in our judgment because there is no connection between the two things. We feel we might have rested our case and asked for a non-suit, on the ground that the plaintiff had failed to make out a case. Naturally, we did not do this, but, as has been stated, we not only endeavored to show that we could not have done it, but that we did not do it, and we might well have rested at this point. We went even further, however, to the perhaps unnecessary extent of showing what actually did cause the damage.

It is rather difficult to predict any outcome and perhaps you are not especially interested in that, not so much as we are, anyway; it is difficult to sever one's hope as to what the outcome will be from one's thought in the matter, but it looks as though we have pretty clearly established with some degree of scientific accuracy the effect of blasting vibrations on structures, and the whole thing has rather clearly indicated to quarry men the method of approach in the defense of just that sort of case.

President Eames Testifies

I neglected to say one thing that I wanted to say. We know the activity of our president (Mr. Eames) in the various lines of interest connected with our association, but I do want to tell you this, and I know that most of you don't know it: He was one of our most valuable witnesses; he came up to Boston and told of his operation, of his plant in New Haven, and aired all his secrets of operation for our benefit and was of real and actual service to us along the line of expert quarry testimony as to how a quarry should be properly conducted.

Selling Agstone in Indiana

By Prof. W. A. Ostrander
Indiana Agricultural Experiment Station

IN Southern Indiana last summer we spent just three days in a limestone campaign and put a real punch back of it, and got a salesman in there. We wanted a limestone trade and the county agent of the farm bureau said it couldn't be done. We held three township meetings and had more carloads than any engine on the Southern Railroad can pull—46 cars—and that is the first time I ever saw men fight because they couldn't get limestone. Some fellows ordered two cars. When the train was coming in it got a lot of publicity; other fellows wanted to be in line; they were ashamed not to be; it was the swim. They were in the elite class to have a carload of limestone coming. They were not ashamed of it, as I think a good many have been in the past, and men actually got into arguments, and pretty physical ones, to try to get a carload away from those that had two. Now that has changed the attitude in that county, and since that happened, 2400 tons went into that county in less than two months.

In another county they called themselves poor old prairie farmers; they had never used 200 tons of limestone in the county. Last year, in four months' time, by getting a salesman in there and working it, we sold 2300 tons. I believe that is getting results. We extension men shoot with blunderbuss when we go out to sell limestone. Up in Marshall county, Indiana, we were on a tour and we put a placard on our car and I will guarantee every time we stopped there were two or three men getting limestone from us.

Maybe Mr. King has hit the proposition when he has a salesman in every township; maybe that is what we want.

Discussion of Quarry Transportation

By F. T. Gucker

MR. ROCKWOOD wrote and asked that we have a few photographs here showing the use of motor trucks in hauling from the quarry to the crusher. Unfortunately, I didn't get his letter until our season was over, so I will show a few views of the quarry and you will have to take my word for it that the trucks are operating there.

Fig. 1 shows operations on three different levels. Each dip is about 20 ft. high; we haul up about a 10 per cent grade to the crusher.

Fig. 2 is another view of the three levels and the plant at the left.

Fig. 3 is a view down on the second level, showing the face there and the drilling operations going on.

Fig. 4 is a drainage tunnel from the lower level, showing the more distant operation.

Fig. 5 is one of the small trucks.

Fig. 6 shows the way we put in storage by the use of trucks. We have a wooden track here on which the truck backs up.

Fig. 7 shows one of the trucks backing up on the pile.

Fig. 8 shows the pile that has been made of 1-in. stone that couldn't be sold last year.

Fig. 9 shows a truck dumping it at the top of the pile.

Fig. 10 shows a truck loading at the concrete bins.

Fig. 1—Three levels now being operated

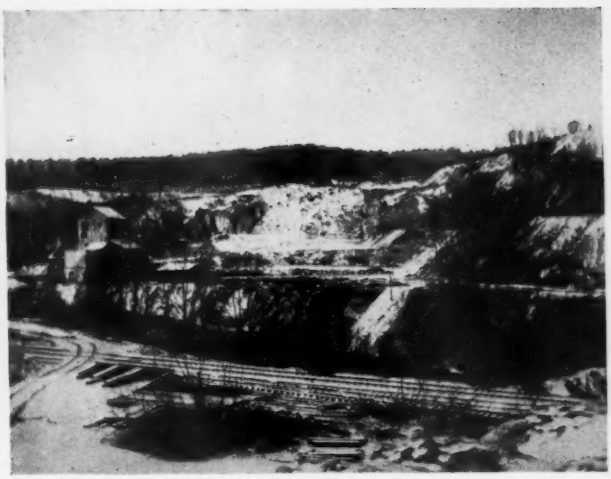


Fig. 2—View of plant and three levels

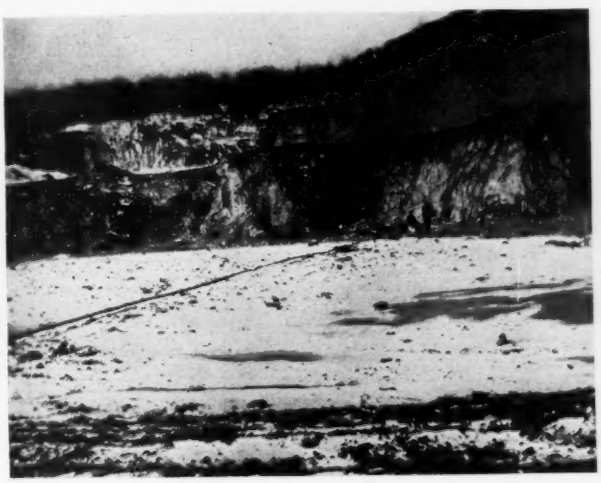


Fig. 3—Two levels. Old quarry floor and about 20 ft. lift below

Fig. 4—Drainage turned for lowest level

Fig. 5—Truck hauling from plant. Note the concrete bins

Fig. 6—Truck on storage pile

Fig. 7—Truck on storage

Fig. 8—A storage pile

Fig. 9—Dumping at storage pile

Fig. 10—Truck under concrete bins built in 1906

Discussion of Quarry Transportation

By Norman Hely, Cape Girardeau, Mo.

GENTLEMEN, I don't hardly feel capable of discussing the question before us because I have some very strong opinions on quarry transportation. In other words, I think it is the whole quarry business in getting stone from where it is loaded, regardless of the method, into the crusher. We all use some type of quarry transportation and we all use one of three or four kinds of drilling and blasting and one of two or three methods of loading the stone and one mechanical means of crushing the stone, but Mr. Rockwood says there are 2000 producers of crushed stone in the United States, and I imagine there are 2000 different methods of quarry transportation.

This problem, I think, is covered in lots of ways, and it must be met by the individual producer, taking into consideration the amount of his production, the type of his quarry and the drainage and a thousand other things.

I think the most valuable part of quarry transportation is time. Naturally, an investment has to be made in whatever type of equipment is used, and why I say time, I don't think it takes any longer if the right methods are used, or any more trouble or any more expense outside of the initial investment, to dump 20 yd. of stone into a rock crusher than it does to dump 1 yd. It can be done in approximately the same length of time.

We have a plant where we have tried to get a large production and our quarry methods have been the reason for our production, whether it was small or large. The plant can be added to. We have a plant that now I think is way ahead of what we will ever be able to produce with a quarry.

Now there has been nothing permanent, I might say, in our method of quarrying or nothing permanent in our transportation problems. We are cramped. Right through our property is a very important public road—Kings Highway of the South—that runs right under the plant. The main line of the 'Frisco railroad is right under our conveyor bridge. We have opened up now a space of about 5½ or 6 acres which will be all the space that we will ever have. We are now going down on three different levels.

I am sometimes asked by the people around there how much stone we have. Well, some very generous concern thought there was about $40,000,000 worth of oil under this property before we had it and were very kind to drill a thousand-foot well

through this rock for us and leave the log for us to determine the amount of rock there.

Hand-Loading Experience

Our method has practically all been hand-loading. The quarry falls to the north in a 5-deg. incline, so in taking a car to the crusher it is pulled there by a locomotive—a team of mules, and the man comes back with the car using a brake, bringing the car back to his own track on its natural and gravity fall.

We have tried to work out a proposition of 6-yd. cars, but we have a grade of 5 per cent, and if anybody can advise me how to put a system of tracks and a locomotive big enough to pull 6-yd. cars up that grade into the crusher in the small place available, I certainly would like to have the information.

Adopts Motor Trucks

We have worked out everything and, in fact, we are starting an absolutely new plan that I am not able to talk about because it started yesterday morning.

We are putting a steam shovel—a 1½-yd. shovel—and loading into 5-ton dump trucks. We don't need any track, eliminating all of that. We have the best road in the world on the quarry floor and always will have, and those trucks are hauling to the crusher.

Costs of Hand-Loading

We build our cars in our own shop. We dump them in two ways, either by bringing them up an incline and the gate lifted by a rail or a home-made tipple arrangement that we have. In hand-loading, naturally the car had to be low. We have men there that will average between 40 and 60 yd. a day. We pay by piecework for that type of car. The cheapest we have ever gotten it for was 20 cents a car. During the peak of prices it cost us 40 cents a car to get them loaded. It is now costing 30 cents.

Mule Harness Kink

We have worked out a kink that is probably not very interesting to people that are fortunate enough to have a real locomotive, but a simple harness and tree we made, probably has solved more of our transportation problems than anything else. We have the team of mules with a double-tree made out of pipe with chains attached to it. It is very heavy. In going over the tracks, switches, frogs and things that would drag, break, throw a mule, perhaps hurt him, tear up the harness, so our team spent most of the time in the blacksmith shop being fixed up. Now that also meant that that man could not pull as many of those 2-yd. cars to the crusher in the run of a day's time as he should. If he could have some type of harness that was easier for him to handle, it would mean more to our transportation, we thought, than anything else.

So we figured out this type of harness which I imagine would be interesting to anybody that uses this kind of locomotive. We have a stiff arm, a very light double-tree in the back that the mules hold up; it is swung over with a strap in the back and the mule carries it all. There is just a light chain that the man can either hang on the double-tree when he is going around or carry in his hand. That is a very small feature, but I think it meant more to the efficiency of our locomotives than anything we have been able to figure out.

On the southern end of our quarry we have a fall to the crusher. In that way a man brings his stone to the crusher and merely uses a brake that will come down to the crusher and the cars are taken back with a single mule.

We first had in our plant a No. 8 and a No. 6 set of rolls before we got down into the ground much in our development. We got to the point where our crusher must be closer and the stone could be handled mechanically from the crusher and not be handled through cars or things of that kind. We installed a No. 12 and put it at that time 25 ft. below our main operation. At the present time it is above.

Small Revolving Shovels in Quarry Work

By A. C. Vicary
Vice-President, Erie Steam Shovel Co., Erie, Pa.

I HAVE with me a few slides showing some small shovels in quarry operation throughout the country that may interest you. A good many of these shovels I believe are operating in plants which are owned by various members of your organization, and you will doubtless see some familiar pictures as these are shown on the screen.

Fig. 1 is an installation showing a ¾-yd. shovel being operated by the Connecticut Quarries Co. It operates seven of these small units in its various plants, and in talking with Mr. Worthen, vice-president, he told me that it was almost unbelievable that a small machine of this kind could stand the gaff of such rough quarry work. He told me that in one of their plants they were averaging approximately 65 tons per working hour with this small unit.

Fig. 2 is another installation of the Connecticut Quarries Co. handling rock on faces 100 or more ft. high, and the conditions are very severe.

Fig. 3 is still another installation showing the nature of the conditions which are being encountered.

Fig. 4 is an installation at the Lane Quarry plant at Westfield, Mass., where approximately the same conditions are being encountered as in the Connecticut Quarries plant.

Fig. 5 is a ¾-yd. machine owned by the American Lime and Stone Co., Huron, Pa. It is operating a number of these smaller units in its operations.

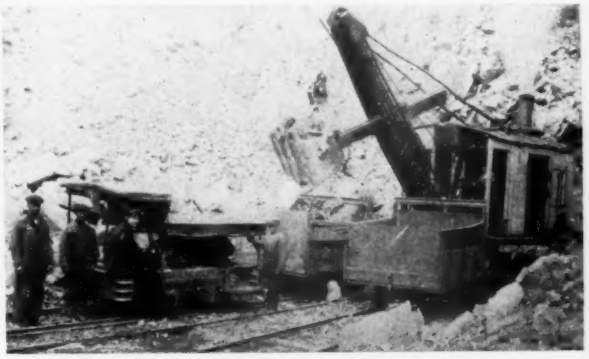


Fig. 1—A ¾-yd. shovel working in trap rock at quarry of Connecticut Quarries Co.

Fig. 6 is a ¾-yd. machine being operated by A. Tarbox & McCall, Findlay, Ohio, in a limestone quarry. Mr. Tarbox happened to be at Erie just a very few days ago. This machine has been in constant operation for the last six years and he told me that last season when they were pushed for material and had to run the machine up to the limit of its capacity they were handling approximately 100 tons per hour. That is a very large output, but of course they had a very efficient operator on the machine and the means for taking away the capacity of the machine. He said he was very much surprised to think that he could handle any capacity like that, but they had to get the stuff out and the machine got away with it.

Fig. 7 is a quarry operation up in Canada, the Dufferin Quarry, near Toronto.

Fig. 8 is a limestone operation down in Yellow Springs, Ohio, a rather small quarry. The material comes down in pretty big chunks, which are lifted out of the way by the shovel and the rest handled in cars.

Fig. 2—Working in trap rock

Fig. 9 is a Thomasville Lime and Stone Co.'s operation near York, Pa. They are operating four of these small units in the quarry and have a crane on top stripping. These little machines can be converted into cranes quite readily and very adaptably; the small units can be put into operation at almost any angle; they are very portable and very reliable.

Fig. 10 is a little ½-yd. machine, a little baby, the smallest machine of this kind built, and for some small quarry operations they have produced remarkable results. These small machines are really fully as reliable as their big brothers, but of course the output is naturally considerably less.

Fig. 11 shows the shovel converted into a crane with a 36-ft. boom and a ¾-yd. bucket handling crushed stone. Frequently these small units can be pressed into service of this kind around any crushed-stone plant

Fig. 3—Another view of trap-rock quarry

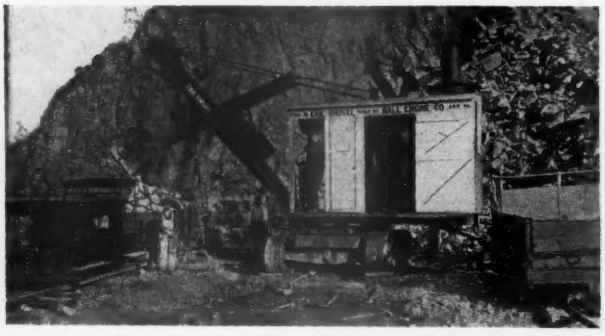


Fig. 4—Lane quarry, Westfield, Mass.

Fig. 5—American Lime and Stone Co., Huron, Pa.

Fig. 6—Tarbox and McCall quarry, Findlay, Ohio

Fig. 7—Dufferin quarry near Toronto, Ont.

Fig. 8—Quarry at Yellow Springs, Ohio

Fig. 9—Thomasville Lime and Stone Co., York, Pa.

Fig. 10—A ½-yd. shovel, the smallest in quarry work

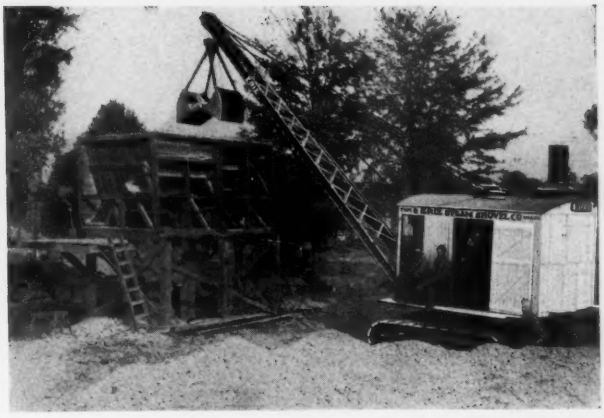


Fig. 11—A converted shovel-crane attachment

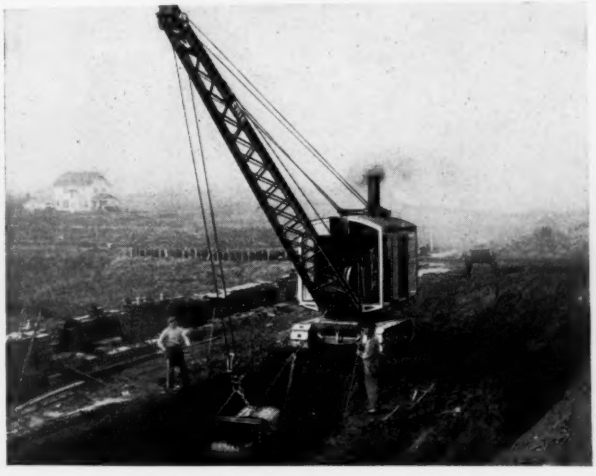


Fig. 12—Converted shovel on stripping work

Fig. 13—A new departure, a ditching shovel

or practically any quarry operation. They make a very handy little adjunct.

Fig. 12 isn't a quarry stripping proposition, but frequently these small converted draglines can be used in quarry stripping.

Fig. 13 is a new departure in the steam-shovel field. The machine stands on solid ground and the dipper is pulled in in sort of a hoe action which makes it unnecessary to support the machine over a trench. This probably would do many stripping operations.

How to Promote the Use of Agstone

Extracts from the talk of Prof. A. W. Ostrander at Agstone Luncheon

IT is discouraging sometimes to find the price of limestone going so low and to know that the same farmer is going to have to pay two or three times that much in a few years. I am wondering how it is going to set up. Now I am not pleading for a low price of pulverized limestone today. I believe we have worked out our freight rates pretty well in Indiana; it is high in places. But the thing I am getting at is this: There are communities that are buying limestone, and a lot of them, in spite of the price and in spite of the freight rate. How is it done?

It is true that some farmers think they haven't the money to buy limestone. As I tell them, when they want limestone as bad as they want Fords, they will get it—if they had to break their back or their neck they would get it—and you don't see any Ford laid up in the garage because John D. put the price of gasoline up a cent. It is used because they want it.

I wish we could get a bunch of our county agents to come in here, because they get some peculiar ideas about limestone producers; they used to have some peculiar ideas about our railroads until we began to smooth that off. We had ten counties down in the Terre Haute district and we got together to solve the limestone problem.

They were not using limestone, and it took us six months to get them started. They spent most of that time cussing the producer and the railroads; they said that was the whole trouble, so we brought all of our producers down to the meeting and said, "There they are; go ahead and say to them what you said to us"; and when they came out of that meeting they were working together, and they have worked together ever since, and the day hasn't been too long or the roads too bad or the weather too bad for the producers to get down into that territory to help those county agents out if they needed it, and I have ridden with them through rain, and they have gone there.

Then they said it was the railroads' fault, so we asked the agricultural agents of the railroads to come down. The New York Central was there; the I. C., the C. & E. I., the Pennsylvania men were there, and we told them to go ahead and tell them what they told us, and when they got through, the railroads saw our problem, and they began to appreciate the fact that lime bins were the solution. And Clay county has moved from a thousand to fifteen hundred tons a year through three lime bins in the sections where there never was limestone moved before, because they have solved that problem. Those things are working out as our producers and county agents and our colleges get together.

Gasoline Quarry Locomotives

By H. R. Sykes
Sales Manager, The Fate-Root-Heath Co., Plymouth, Ohio

IT is safe to assume, I think, that it is a matter of common knowledge among the members of your association that gasoline locomotives have been used for years with great economy and efficiency in the largest as well as small quarries. They are used for stripping, gathering and main haulage, and in many cases for handling the finished product in various forms from mill to loading point.

At Kelley Island Lime and Transport Co.'s plant

One 3- or 4-ton locomotive and one man in many quarries are doing twice the work that four men and four horses or mules formerly did, or the equivalent of eight men and eight horses. This, at a small part of the cost of the former method, as the wages of one man and the expense of 5 to 7 gal. of gasoline per day and a little oil will take care of such work. The investment will be no larger, and in many cases less. A direct saving of $20 per day in this way is very easily possible and on nine months' operation that will pay a 6 per cent dividend on $75,000. Correspondingly larger results, of course, follow the use of more, or larger, units. The indirect saving, through speeding up loading operations through keeping cars moving faster and cars waiting for loading, should be apparent to each one on his particular operation.

Gasoline locomotives, on account of being lighter than certain other types, can be hoisted and moved about quite easily so that one locomotive can often be made to serve a double purpose about a quarry, through being used in stripping work at certain seasons, and then for hauling on the floor again. They are particularly adapted for stripping work because, owing to their light weight, they can be operated on track laid on new fills and are easy on the portable track. They are quick in action and in the case of properly designed ones will return the empty cars faster than the loads can be taken out.

In handling rough stone on the quarry floor they are decidedly economical and efficient, on either long or short haul, 300 ft. not being too short to be fully practical with proper track layout. A small amount of fuel supplied once a day, which a man can carry to it, and a little water and the trouble and expense in that respect, are over for the day. The nature of the water, whether alkaline or not, need not be considered, as there are no flues to be eaten out and replaced at regular intervals. They are ready for operation each morning with a very few minutes' attention, it not being necessary for the operator to be on hand an hour or so before the whistle blows, nor is a licensed engineer required. If Tom isn't on the job this morning, Dick or Harry can take his place. They require fuel only while they are working, so if the steam-shovel or the crusher should be tied up for an hour or so, just tell Tom to "shut her off."

The wide, general use and dependability of present-day gasoline engines in industry generally at once removes any properly designed gasoline locomotive from any suspicion of lack of dependability. The far more simple design and sturdy construction make them more dependable than the sturdy auto-truck, which is today doing nearly 90 per cent of the country's trucking.

Some difference of opinion exists among users as to the size most practical and economical, considered from all angles, but it is coming to be quite generally conceded that, where grades in track will permit, the use of two small units is more desirable than one large one. This, of course, involves one more man, but through keeping cars moving faster, the work of a number of others is speeded up and this expense more than offset. Again, if depending upon one or more large ones, should one be put out of service in any way, the effect on the plant production is much more marked than if this should happen with small units in service.

At the Bethlehem Mine Co.'s plant at Steelton, Pa.

A few reports of concrete causes of the use of these locomotives in quarry work will, no doubt, serve to bring out more forcibly their economy and efficiency. Those cited are taken at random from our files, but only cases where only one unit is used, or only one unit cited if more than one is used, are employed so as to make them applicable to either small, moderate or large quarries.

The Broken Sword Stone Co., Bucyrus, Ohio, handle on a 2000-ft. haul involving

some 2 per cent grade, 14 tons of material with a 3-ton locomotive in about three minutes—a total of 500 to 700 tons per day, using about 7 gal. of gasoline.

The Kittanning Limestone Co., Kittanning, Pa., with a 3-ton locomotive handling 14 tons per trip, report a total cost of operation and maintenance on an average over three seasons of .0358 cent per ton.

The Solvay Process Co., Syracuse, N. Y., report handling with one 3-ton locomotive 22 tons per trip over ½-mile haul involving some 1 per cent grade, or a total of about 650 tons per day, using about 7 gal. of gasoline.

St. Marys Cement, Ltd., St. Marys, Ont., report handling with one 6-ton locomotive 1000 tons per day over a considerable haul involving some 5 per cent grade.

The Morris County Crushed Stone Co., Morristown, N. J., report handling with one 3-ton locomotive over some 3 per cent grade, 6 tons of crushed stone per trip, hauling from crusher to loading point. This, however, involves speed rather than tonnage.

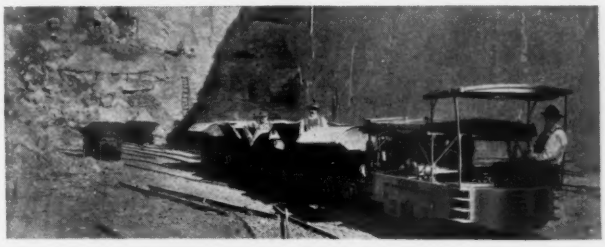
Meshberger Bros., Berne, Ind., report handling with one 3-ton locomotive 500 tons per day on 700-ft. haul, using 5 gal. of gasoline.

The Bethlehem Mines Corp. (subsidiary of the Bethlehem Steel Corp.), using eight 3-ton locomotives on a circular track, report on a speed operation handling 2 tons, 600 ft. in 40 seconds, making, at times, as many as 200 trips per 10 hours, although, as a rule, these locomotives run continuously night and day from Sunday night until the following Saturday night.

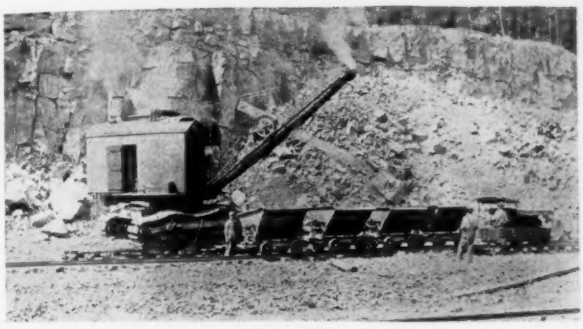
The Three Forks Portland Cement Co. at their Hanover, Mont., plant report handling with one 3-ton, 600 tons per 8 hours, partly on a slight down-grade, using 4 gal. of gasoline.

The foregoing should serve to permit any quarry operator to estimate quite closely what he could expect from gasoline locomotives in his particular operation, and the lantern slides which will now be shown, some of which cover cases cited, may show an application similar to your haulage problem.

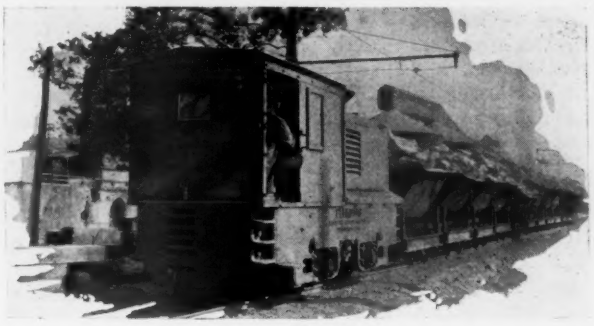
At the John S. Lane Son plant, Westfield, Mass.



At the American Lime and Stone Co.'s plant, Bellefonte, Pa.



At the Morris County Crushed Stone Co.'s plant, Morristown, N. J.



At the Charles Warner Co.'s plant at Wilmington, Del.

Organization of the Manufacturers' Division of the National Crushed Stone Association at Chicago, Ill., January 16, 1923

AT a meeting of the Associate Members of the National Crushed Stone Association held January 16 the following organization was completed:

N. S. Greensfelder, Hercules Powder Co., chairman; C. G. Buchanan, C. G. Buchanan Co., first vice-chairman; W. A. Farrell, Easton Car and Construction Co., second vice-chairman; Nathan C. Rockwood, Rock Products, secretary and treasurer.

In addition to these officers, the following were elected to the board of directors: H. T. Gracely, Marion Steam Shovel Co.; Thomas Robins, Jr., Robins Conveying Belt.

The following resolution was passed:

Whereas: The manufacturers of machinery and materials are vitally interested in the problems of the National Crushed Stone Association,

Whereas: The companies which have already become associate members of the National Crushed Stone Association realize and appreciate the opportunity of the cooperation with producers of crushed stone which such membership affords, therefore

Be It Resolved: That the officers and members of the manufacturers' division of the National Crushed Stone Association hereby pledge themselves to vigorously assist the Membership Committee of the National Crushed Stone Association in securing additional active and associate members and hereby instruct the officers of the manufacturers' division to meet with the officers and Membership Committee of the National Crushed Stone Association to lay out a plan of action for a membership drive during the coming year.

Rolls as Primary Breakers

By Brownell McGrew
Engineer, Allis-Chalmers Mfg. Co.

THE roll principle was first applied to crushing in the mining industry where smooth-faced double rolls have been used for many years in the secondary reduction of various ores preparatory to concentration. Another old and well-known application of the same principle is the double-spiked rolls used for crushing coal for stoker firing, etc.

In the first-mentioned instance the rolls have the same fundamental action as the gyratory and jaw—that is, a straight pressure crushing action. The maximum size of feed is determined primarily by the diameter of the rolls, the spacing, and, for any given material, by the angle of nip which is a function of the coefficient of friction and the hardness of the material in question.

The spiked coal crusher does its work in two ways; first, the larger lumps are torn apart by the spikes until they are reduced to a size that the rolls will grip; the secondary action is precisely similar to that of the smooth-faced rolls. It is to be noted, however, that the angle of nip is greatly increased for any given diameter, due to the spikes themselves.

Double Rolls

About 30 years ago Thomas A. Edison conceived the idea of applying the roll principle to the primary reduction of shovel-loaded ore with the idea in mind of building a crusher capable of receiving larger stone than any jaw or gyratory that had been developed at that time.

Mr. Edison's first machine seems to have been a direct descendant of the spiked coal rolls, although the rolls were much larger and the construction of the machine vastly stronger throughout. Also, instead of spikes beveled knobs were utilized, these knobs being cast integral with segmental plates attached to a polygonal center.

It was found, however, that when a rock was fed into the machine larger than the rolls would grip it would ride on top of the rolls and rapidly wear off the knobs. To obviate this difficulty one of the rolls was fitted with two rows of knobs diametrically opposite each other and about 1½ in. higher than the regular knobs. The function of these knobs was to exert a powerful sledging action on those blocks of stone which were too large for the rolls to grip and thus reduce them to pieces which could be gripped by the regular knobs. This expedient proved eminently successful, and the next step taken was that of speeding the rolls up to augment the sledging action and likewise the kinetic energy

The largest size developed up to the present time have rolls 6 ft. in diameter by 7 ft. long and a receiving opening 7x7 ft. Their normal speed is 185 r.p.m., giving a surface speed of almost 3500 ft. per minute.

Their capacity is enormous, exceeding by a considerable margin that of any other crusher yet developed. In a test made some years ago at one of the plants of the Kelley Island Lime and Transport Co., 35 tons of stone were crushed in 32 sec., or at the rate of about 4000 tons per hour. The writer has timed a set of 6x7 ft. Edison rolls on cars of stone running from 9 to 10 tons, the average time being 13 sec., or at the rate of 2700 to 2800 tons per hour. These rolls were crushing to 8 in. and under.

Naturally, in crushing so great a tonnage in so short a period, the energy delivered by the rolls is high—so high, in fact, that it would be out of the question to provide sufficient motive power to take care of it. For instance, the usual practice when driving the 6x7 ft. Edison rolls electrically is to belt the slugger roll to a 250-hp. motor and the regular roll to a 200-hp. motor. Now, when a car load of stone is dumped into the machine the instantaneous energy delivery may be as high as 4000 hp., which is obviously far beyond the capacity of the motive equipment. But the rolls themselves, when running at normal speed, have a stored kinetic energy of approximately 4,500,000 ft.-lb., and it is this kinetic energy that does most of the actual crushing, the motors serving to bring the rolls back to speed between the crushing periods. In crushing an 8- to 10-ton carload of stone the rolls may lose anywhere from 30 to 60 r.p.m. in speed. This loss occurs partly through slowing down of the motive equipment and partly through belt slippage. It requires from 5 to 10 sec. to bring the rolls back to normal speed, during which time the power input will vary from 400 to 600 hp. The power required to pull the rolls when empty is something less than 100 hp., depending upon the condition of the bearings, lubrication and temperature. The average power consumption when crushing from 3000 to 4000 tons per 10-hr. day will be in the neighborhood of 150 hp.

It should be noted that the total horsepower-hour consumption of the Edison rolls compares favorably with that of other crushers turning out an equal tonnage. It is natural to expect, however, when the rolls are driven electrically that the rather violent power fluctuations outlined will result in a low power factor and numerous high peaks, an objectionable load from the standpoint of the small central station or individual power plant. These peaks may be smoothed out somewhat by installing automatic overload trips to cut the power off the motors when the load reaches a predetermined maximum, cutting it back in when the crusher is empty. This has been done in one or two instances where the power contract carried a penalty for excessive peak load conditions.

The type of quarry equipment most commonly used in conjunction with the Edison rolls is the three-sided steel skip—or scale box—resting on a flat-topped truck or on a regular flat car, in which case three or four boxes may be placed on one car. These skips have a shackle riveted to the rear end and this shackle is engaged by a hook actuated by a small hoist, which slides the skips over against the lip of the receiving hopper and tilts them so as to discharge their contents.

From the skips the stone passes over a feed roll, which retards the flow and delivers the stone to the crusher at a fairly uniform rate. When the skip is empty it is pulled back on to the truck or car by a counterweight attached to the opposite end of the same cable which leads to the hoist.

A heavily ribbed hopper surmounts the frame and extends up to the level of the feed roll. This hopper serves the double purpose of directing the material into the crushing zone and preventing stones thrown by the sluggers from flying out of the crusher. It has also been found necessary to cover the top of the hopper with heavy netting or other protective material to protect workmen from flying spalls.

On the 6x7-ft. rolls the hopper used in conjunction with the skips mentioned is vertical on all four sides and has no projecting lugs or other protuberances to hinder the flow of rock. The construction of this hopper, together with the violent agitation in the crushing zone, minimizes blocking and bridging. On the other hand, when bridges occur down in the hopper they are difficult, and sometimes dangerous, to break unless the rolls are shut down and the stone lifted out—all of which means loss of time.

One of the questions commonly raised by the prospective purchaser of a crusher has to do with the head room required to properly install it. Here we have to take into consideration what is probably the most pronounced characteristic of the Edison rolls as compared with competing types of crushers—that is, the extreme rapidity with which they pass through a car of stone. It is, of course, out of the question to provide elevating or conveying equipment capable of handling peak loads at the rate of 3000 or 4000 tons per hour when the balance of the

plant is designed to handle perhaps 300 or 400 tons per hour. Therefore, if either pan or belt conveyors are used, some means must be provided for checking the stone beneath the rolls and feeling it uniformly to them.

This is ordinarily done by means of a roll feeder, and a hopper is provided between the feeders and crusher large enough to hold two or three quarry carloads of stone. This all takes up head room and increases the cost of installation so that in this respect the Edison rolls do not compare favorably with either the jaw or gyratory when installed in connection with either of the types of equipment mentioned. When the skip system of elevation is used, however, the total required head room from feed track to the bottom of the skip pit will be about the same as is required for the 84-in. jaw crusher—and somewhat less than that necessary for the large gyratories.

The wearing parts of the rolls themselves are chilled-iron plates fastened to the roll centers with heavy machine screws having special locking devices and provided with heavy splines to take care of shearing stresses. It has been found that in this crusher chilled iron will outwear manganese steel, and the chilled-iron plates are, of course, considerably cheaper.

The cost of plate replacements and other repairs will, as a general rule, be somewhat higher than on the jaw and gyratory crushers operating on similar material, but, everything considered, the cost of operating Edison rolls is quite reasonable when crushing limestone or other material not of a highly abrasive nature. Neither the Edison rolls nor the single roll crusher can be recommended as an economical proposition for extremely hard and abrasive material.

One of the things the prospective purchaser of a crusher is always interested in is the character of product that may be expected from any particular type of machine. With the Edison rolls, perhaps more than with any other type of primary breaker, the product depends upon the character of the material, particularly so with regard to the amount of fines that may be expected. Very little data are available upon which any conclusive opinion can be formed in this respect. Such analyses as have been made, however, would indicate that the product of the Edison rolls will compare favorably with that of competing types when operating on hard and brittle stone, or on stone of a firm structure. On the other hand, the action of the rolls on soft, friable stone produces an amount of fines considerably in excess of that produced by the other types.

Single Rolls

The single-roll crusher consists essentially of two parts: the roll itself and a curved anvil against which the crushing is done. The roll is fitted with knobs, or teeth, the same as the Edison rolls, but owing to the different crushing principle involved these teeth have a different shape. The action of the Edison rolls has been described as being a combination of hammer-mill and crushing roll; the action of the single roll is a combination of sledging and pressure crushing. It might perhaps be better described as being a succession of sledging impulses delivered against the stone as the broken and rebroken pieces work themselves down the curve of the anvil to the discharge point.

The roll runs at a very low speed as compared with the Edison rolls, and no use is made of the kinetic energy of the revolving element other than to absorb instantaneous shocks when the slugger teeth grip a large stone. Very little actual breaking is done on top of the roll except on soft friable stone and on large slabs which lodge against the anvil at one end so that the sluggers exert a cantilever action against them from below.

The front, or crushing, faces of the teeth are radial, or normal to the line of action, and to further aid in the gripping of large pieces the teeth are made of different heights. From two to four rows of slugger teeth are used, the balance of the rows being so called "regular," or low teeth.

When a carload of quarry-run stone is dumped into the single-roll crusher the following stages may be observed: First, there is a pronounced selective action; the smaller pieces of stone separate themselves from the larger and sift down through the mass into the crushing zone, where they are gripped and forced through the discharge opening.

During this process the large pieces are shoved up and held away from the roll by the mass of smaller pieces. As the crusher clears itself of the small stone, the larger chunks come down into the zone of action—first the one-and-two-man stone, and finally the large blocks and slabs, which may be any size up to the maximum which the crusher will receive. Large slabs will generally be up-ended and thrown against the anvil and the back of the hopper, where they are held while the slugger teeth gradually reduce them to crushed stone.

Naturally, during this process the agitation in the crushing zone is very violent, and herein lies one of the most favorable features of the single-roll crusher, as this agitation reduces the chance of bridging to a

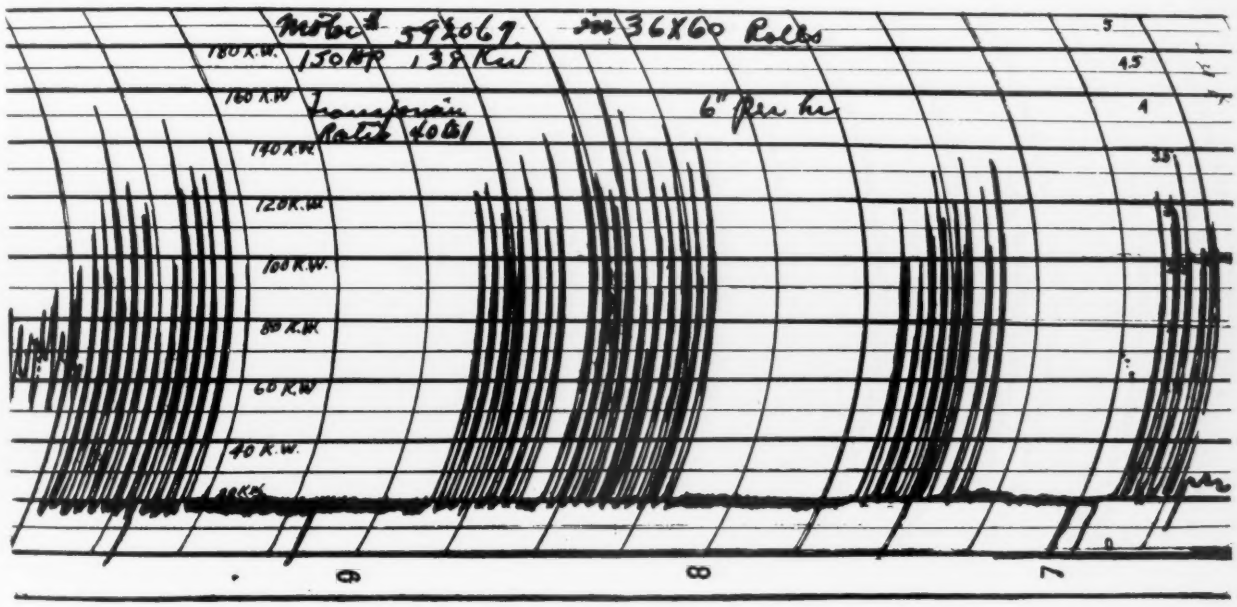


Chart showing the electric-power consumption of Fairmount roll crusher

minimum and makes the crusher to a large extent self-feeding. Frequently such bridges as may occur can be broken by the simple expedient of throwing in a single piece of stone of sufficient size to raise the bridged material as it passes between it and the roll, or by dumping a car of small material, the selective action described tending to raise the bridge.

Blockades caused by single stones too large to enter the crushing zone are a more serious matter and are generally more difficult to break than in the gyratory or jaw crusher, due to the fact that the process requires some care to eliminate the element of danger unless the rolls are shut down.

On the whole, however, very little difficulty will be experienced in feeding the single-roll crusher if proper equipment is provided for turning over such stones as may enter the hopper at the wrong angle and for breaking any bridges that cannot be removed by the method outlined.

In regard to the size of stone which can be successfully handled by the single-roll crusher, it may be said that these machines will take care of any width up to the length of the roll and any length which can be handled in the average quarry car. The thickness depends primarily upon the diameter of the roll and also to a considerable extent on the hardness and toughness of the rock.

Fairmount Roll Crusher

The single roll, as developed by the Allis-Chalmers Mfg. Co. under the trade name of "Fairmount crusher," is built in three sizes, namely, 24-in. diameter by 60-in. length, 36-in. diameter by 60-in. length and 60-in. diameter by 84-in. length.

The 24-in. roll will handle rock from 12 to 16 in. in thickness. The 36-in. roll will handle rock up to about 24 in. in thickness. The 60-in. roll will take in ledges 48 in. or more in thickness, depending on the hardness and toughness of the material.

The capacity of the single-roll crusher is a variable factor, depending upon the character of the rock and the size of feed and product. The 24x60-in. Fairmount roll running at 58 r.p.m. has a capacity of from 200 to 400 tons per hour on limestone of medium hardness crushing to 6 in. and under, the average power consumption being in the neighborhood of 100 hp. The 36x60-in. roll, running at 39 r.p.m., has a capacity of from 250 to 350 tons per hour, crushing to 8-in. and handling medium limestone where the strata do not run over 20 in. in thickness. The same machine has a capacity of from 400 to 700 tons per hour on medium limestone where the strata do not exceed 16 in. in thickness. This size of machine has been known to produce continuously over a period of several months an average of about 450 tons per hour.

For average conditions the machine can be driven by a 150-hp. motor, the average power consumption under load being in the neighborhood of 110 to 120 hp. A recording wattmeter chart taken from a motor driving a single-roll crusher will show a succession of instantaneous peaks for each time that the sluggers grip a big stone. These peaks may run as high as 250 hp. on the 36x60-in. machine, but they are of such brief duration that they are not objectionable. The average load fluctuations will lie between 80 and 150 hp.

The 60x84 in. roll running at 23 r.p.m. has a capacity range of from 1000 to 1500 tons per hour, crushing to 10 in. and under, with an average power consumption of from 250 to 300 hp.

In the matter of head room the single-roll crusher has a slight advantage over the jaw and gyratory crushers when installed in conjunction with the pan or belt conveyor. It has some advantage over the jaw crusher and a substantial advantage over the gyratory when the skip system of elevation is used. Its crushing rate is sufficiently uniform to permit feeding direct to pan or belt conveyor without intervening feed regulators, an advantage which it enjoys (in common with the jaw and gyratory) over the Edison rolls.

On stone for which they are adapted the cost of maintaining single-roll crushers compares very favorably with competing types. When crushing hard or abrasive material, however, the cost of tooth replacement is so high that the single roll is not an economical proposition; and this is also found to be the case if the machine is required to crush ledges too thick for the sluggers to grip, as the large pieces riding on top of the roll grind off the tops of the teeth rapidly.

When the Fairmount crusher was first brought out the roll was equipped with removable plates attached to an octagonal center, the method of attachment being similar to that used on the Edison rolls. The square-faced teeth, however, transmitted such severe shocks to the roll that considerable difficulty was experienced in holding the plates on the roll center. The crusher is now equipped with renewable manganese or tool-steel teeth inserted in a cast-steel center. This is not only much stronger than the plate design, but it has the added advantage of effecting a great reduction in the weight and cost of new wearing parts.

One feature of the single-roll crusher that will recommend it to many operators is the fact that this machine will produce less fines than any other type of crusher. A study of the crushing action will reveal why this is so. In the first place the small quarry spalls are "jigged" out of the load and are quickly ejected through the discharge opening with a minimum of grinding and crushing against adjacent spalls. Secondly, the action of the sluggers on the large pieces is a quick, positive sledging, and as soon as spalls are sledged off they are carried down the curved anvil, subjected to a succession of clean-breaking blows, and rejected from the machine immediately when reduced to the required size. Thus the crushing zone is kept clear of stones which are under the size of the product for which the machine is set and the "masticating" action of the jaw and gyratory is almost entirely absent.

Another characteristic which the single-roll has in common with the double-roll crusher is its ability to handle wet and sticky material. Either the double- or single-rolls will operate at full capacity on material which would choke or greatly retard the output of a gyratory or jaw crusher.

The foregoing description of its characteristics will make it clear that the single-roll crusher has a more limited range of adaptability than any other type of primary breaker. They are suitable for reducing limestone, dolomite, magnesite, phosphate, shale, and materials of similar nature where the crushing strength does not exceed 15,000 to 20,000 lb. per square inch and the ledges do not exceed in thickness the maximum for which the machine is designed.

They have been widely introduced into the portland cement field for use as primary breakers, and in this field they have been eminently successful. The two original 36x60-in. Fairmount crushers installed in the Fairmount plant of the Casparis Stone Co. in 1911 crushed approximately 2,500,000 tons during 1912 and have operated continuously since that time.

Some failures have resulted through misapplication—and there are, doubtless, other installations "getting by" where another type of breaker would be far superior for the given conditions. Due to their limited scope, it is necessary to exercise care and discretion in examining operating conditions to determine whether the crusher will successfully meet them.

On the whole, however, the record of the single-roll crusher is very good indeed, and it can be truthfully said that "on their own home grounds" they have no equal.

Conclusion

I have endeavored in the foregoing to give an unbiased exposition of the characteristics of the double- and single-roll crushers and to note both their advantages and their limitations as compared with the gyratory and jaw crushers. I have always contended, and still contend, that there is no "universal" crusher—no one type that is best under any and all conditions. Each type has its good points and its weaknesses, and a frank portrayal of these points will in many cases save both the operator and the machinery manufacturer a lot of time, trouble, and money.

In the long run any machine must stand or fall on its merits, and the fact that the jaw, gyratory, and roll crushers are all "alive and kicking" is conclusive evidence that there is a field for each of them—and room enough for all of them.

The Jaw Crusher as a Primary Breaker

By C. G. Buchanan
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IN this paper I have mentioned, for comparison only, types of primary breakers as differing from the standard jaw crusher, and why, in my opinion, these types are not so well adapted for treating large pieces, usually of hard, abrasive rock or ore, as the jaw crusher.

I do not wish it to be understood that my criticisms apply to conditions other than those under discussion. It is a well-known and undeniable fact that each type of machine has its own particular merits and distinctive features of great value under certain conditions. Therefore, in making a selection from various types of machines to perform a certain work, it is always desirable to analyze very carefully the duty that is to be imposed upon the apparatus and the adaptability of the machine to be selected to economically perform that duty.

The Primary Breaker

At the present time, when we speak or think of a "primary breaker" as applied to large quarry or mine operations, we invariably associate the breaker as dealing with a volume of a least several thousand tons per day, made up largely of pieces of rock or ore weighing several tons and measuring from 3 to 5 ft. in thickness and from 4 to 8 ft. in length.

In feeding this large mass of irregularly sized and shaped material, the question naturally arises as to the best possible form of opening, crushing action or jaw movement to select in the various types of machines, in order that the rock or ore may be passed through the machine with the least possible amount of wear, loss of time and labor, and to avoid as much as possible the tendency that all breakers have to choke when fed with large pieces of material.

In ordinary blasting it will be found that the majority of the large pieces of rock or ore are rectangular in shape, and therefore it is self-evident that a jaw opening conforming as nearly as possible to the general outline of the fragments of rock to be broken will be the best possible form to select. In the uninterrupted rectangular opening of the jaw crusher, with its upright, absolutely straight convergent jaw opening, these conditions are more nearly met than in any other form of machine now in common use.

Roll Jaw Crusher

It must be admitted, however, that the larger sizes of roll jaw crushers are the nearest approach to the ideal opening of the standard jaw crusher, but, unlike the straight lines of the convergent opening of the jaw crusher, the roll jaw crusher has a curved eccentric opening between the curved surface of the stationary jaw and the circular form of the roll. Therefore, it will not permit of the feeding of as thick a piece in the form of a thick slab as the straight, rectangular opening of the jaw crusher, except possibly on very soft, non-abrasive material. In this case the corners may be "nipped" off or practically worn off by the rotary action of the corrugated roll, thus allowing the material to pass through. As this form of breaker can only be used on soft rock containing only a comparatively small percentage of abrasive material, it does not enter at all into crushing propositions dealing with such materials as trap rock, granite or ordinary ores.

The Gyratory Crusher

Another form of primary breaker is the gyratory, which has advantages over some of the other types for certain special operations. Nevertheless, the form of jaw opening (segments of a circle) which lends itself so well to certain conditions is not so well adapted for handling large rock as the jaw crusher, as it is more inclined to choke, for the following reasons:

The bell or tapering funnel-shaped feed hopper, with its two or three massive spiders or arms directly in the path of the material to be fed between the jaws underneath, is probably the most objectionable form that could be selected, when the object in view is to feed the largest possible pieces with the least amount of choking. Aside from the tendency of the gyratory to choke, there are other objections to its use as a primary breaker for handling large pieces. For instance, the gyratory crusher has a circular feed opening which does not permit of the entrance between the jaws of thick slabs—in fact, the jaw opening called for in listing the size of breaker can never be fully realized in actual practice.

A gyratory with two specified openings —say, 48x125-in. each—could not take in a rectangular piece measuring over 38x66x 66-in., on account of the curved opening. The only form that a gyratory of 48-in. opening would take, measuring 48 in. in thickness, would be a sphere; whereas, a jaw crusher—say, 48x72-in.—would receive and crush rectangular pieces 46 to 48x70 to 72 in.

Jaw Crusher Advantages

The jaw crusher will receive pieces of rock of approximately the full size of the jaw opening, without the objectionable obstructions of the spider arms tending to choke or obstruct the feed, or the contracted effective area of the jaw opening as affected by the circular opening of the gyratory tending to decrease the size of rock that can be successfully handled as compared to the listed opening. For receiving the maximum sized rock—say, pieces measuring 5x7 ft. or more—the first cost of the jaw crusher is less than the gyratory and occupies much less head room—probably not over one-half—which in many propositions is a desirable feature.

The wearing parts of a jaw crusher cost much less to maintain for the reason that in a well-designed breaker the sectional jaw plates can, when worn, be inverted and changed sideways, so that each plate can be shifted in four different positions, in order that the greatest possible percentage of the weight and cost of the plates can be utilized in actual wear. The crushing plates in a well-designed jaw crusher can be changed in less time and with much less expense than any other type, for the reason that the backs and edges of the plates are accurately ground, fitting in machined seats, and do not have to be run in with zinc, which is a slow and expensive process. Owing to the cone-shaped crushing head and concaves, the crushing surfaces of the gyratory cannot be reversed for double wear.

In addition to the advantages, as previously enumerated, I am satisfied from long experience and careful observation that a well-designed and well-built jaw crusher as a primary breaker is by far the most durable crushing device now in use, for the following reasons:

Properly designed, the jaw crusher has less pressure on the bearings, as this type of machine employs a much greater leverage between the eccentric shaft and bearings than any other. In the roll jaw crusher employing one roll, or the ordinary crushing roll employing two rolls, the strain due to crushing comes directly on the bearings.

In the gyratory breaker the crushing is done directly against the eccentric shaft. The lower eccentric shaft bearing, however, is placed below the crushing zone, so that the lower bearing has a leverage usually of not more than 2 to 1—that is, if the distance between the top of the crusher bowl and the bottom or discharge opening was 6 ft., the upright eccentric shaft and bearing would extend about 6 ft. lower down, giving a mechanical advantage or leverage of about 2 to 1. These proportions, of course, vary in different sizes and different makes, but we think that on large primary gyratories the leverage of 2 to 1 is rather in

excess of average practice than below it. In actual practice this would mean that if there was a crushing strain of, say, 1,000,000 lb. between the jaws, there would be imposed a strain or pressure of 500,000 lb. on the eccentric bearings.

When we consider the enormous pressure necessary to crush large masses of hard rock or ore, it becomes evident that if the ratio or leverage can be increased between the crushing surfaces of the jaws and the bearings—thus reducing the pressure per square inch on the bearings—there will be much less wear, less friction and less danger of heating, and a much longer life to the bearings.

In a well-designed primary jaw crusher the leverage between the jaw and the eccentric shaft should never be less than 6 to 1. For instance, in a crusher having an opening of 48x72 in., the movement of the swing jaw, where the heaviest work is done and the greatest strain is imposed, is about ½ in. The throw of the eccentric is from 3 to 3½ in. Thus, through the intervention of the toggle joints it gives a leverage or mechanical advantage to the eccentric and frame bearings of 6 or 7 to 1.

Taking the original comparison formerly noted, we had an assumed pressure of 1,000,000 lb. between the jaws, and in the assumed proportions of the large gyratory, with a leverage of 2 to 1, we had 500,000 lb. on the bearings of the eccentric shaft. Taking the jaw crusher with a mechanical leverage of 6 or 7 to 1, with a pressure of 1,000,000 lb. between the jaws, the pressure brought to bear on the eccentric shaft bearings would be one-sixth or approximately 142,800 to one-seventh or approximately 166,000 lb.

In the large jaw crusher the bearings are longer and have a greater area than those usually employed on either the average roll jaw crusher, crushing rolls or gyratories, and this would indicate a still greater reduction of the pressure per square inch on the bearings.

Size of Bearings

In this paper I mentioned a jaw crusher having a jaw opening of 48x72 in. In connection with the size of bearings it might be of interest to state just what the sizes of bearings are, especially in view of the fact that I have stated in a general way that large, properly designed jaw crushers have, in addition to the advantage of greater leverage, the further advantage of a greater bearing area.

The frame bearings on the 48x72 in. are each 2 ft. 8 in. in length and 16 in. in diameter. The eccentric or pitman bearing is 6 ft. in length and 19½ in. in diameter, giving a total length of water-jacketed bearings on the eccentric shaft of 11 ft. 4 in. With proper care the water-jacketed bearings will last from three to four years and will have crushed, without renewing, two to three million tons of hard trap rock.

I have met in my own practice, and have large primary breakers working successfully on rock and ore, having a crushing resistance of from 43,000 to 54,000 lb. to the square inch. It will therefore be apparent that in dealing with material almost as strong and hard as the materials of construction, every advantage should be taken in the way of leverage to reduce as much as possible the pressure on the bearing surfaces.

To meet these conditions I am firmly convinced in my own mind that for the initial crushing of large masses of hard rock or ore, the jaw crusher has many advantages over all other types and is by far the most durable and economical machine that can be used for this purpose.

Conclusions

In conclusion: The jaw crusher is accessible in every part; all moving or wearing parts are in plain sight and can be quickly adjusted or replaced if worn or broken, and generally without removing any other part. It has a greater range of adjustment than either the roll jaw or gyratory. The opening of the jaws can be increased or diminished to an extent of from 4 to 6 in. without changing the toggles, and—to suit best the nature of the material to be crushed—the stroke or movement of the swing jaw can be regulated to give a jaw stroke of from ½ to 1½ in., and anything between.

All moving parts are provided with adjustment for taking up wear, which cannot be accomplished in some of the other types, so that in a jaw crusher there need be no lost motion, pounding of parts, or reduced capacity owing to loss of motion between the crushing jaws. It is practically a first-motion machine and has only one shaft and one set of bearings. The drive is direct by belt and heavy flywheels, without the intervention of complicated power-consuming countershaft, additional bearings, and high speed gearing.

While possibly it may be out of place in this article on "type" of breaker to say anything about materials of construction, I think, however, that it would not be out of order to give, as a matter of detail, *all* of the features entering into the construction of the highest type of jaw crusher as a primary breaker.

Tough, thoroughly annealed steel castings and forgings, in my opinion, compose the only metal that should enter into the construction of the frames, swing jaws, and pitmans of a first-class primary breaker. If steel, as frequently used, is the best material with which to reinforce cast-iron construction, it is self-evident that it is the best metal to use throughout on all members exposed to direct strain, not only on account of its superior strength (about 3 to 1), but on account of its greater toughness and ability to better withstand the repeated shocks and strains to which crushers are subjected. From a commercial standpoint (of cost) if equal strength and not *dimensions or weight* is required, steel is no more expensive than cast-iron.

I hope the time is not far distant when our good friends, the mine and quarry operators, many of whom are present, will recognize the great value and importance of the primary breaker as associated with the economical and continuous operation of the plant—and also recognize the enormous strains to which the breaker is subjected when crushing hard rock—in order that all builders of "primary breakers" may be encouraged to bring out stronger and more durable machines to meet successfully the very hard conditions under which these machines operate.

While I realize that I am treading on delicate ground, I will risk the opinion that at the present time I am convinced that practically all of the different types of "primary breakers," including my own, are not strong enough and should be made heavier and stronger to meet the conditions for which they are intended. This, of course, would mean increased first cost, but would also mean decreased running expenses and overhead, due to fewer broken parts and the elimination of expensive shut-downs of plant. So that, in the end, the heavier, stronger machine, if well designed, will be by far the most economical.

I look for great improvements in "primary breakers" and feel that, when the subject is better understood, the quarrymen and mine operators will co-operate with the designers and builders so that the present machine may be greatly improved along the lines of greater strength, durability and efficiency and a practically perfect "primary breaker" may be thus developed.

Agriculture the Root of Prosperity

Extract of Talk by Dr. T. D. Bower at Agstone Luncheon

THERE are different kinds of co-operation. I have been interested in what Professor Ostrander has said and the other remarks that have been made here, and I only wish I had time to go into the discussion with you producers concerning the uses, functions, and, we might say, chemistry of limestone in the soil. Now, doctors don't all agree exactly on some of the ideas concerning the use of limestone in the soil. A number of the remarks that were made here this afternoon (on the fineness of limestone) we in Illinois can't quite subscribe to.

Yet, as we view the question today, if we go back about 4000 years we can borrow a saying, or proverb, if you please, from the Chinese people that runs something like this: Public prosperity is like a tree; agriculture is the root, commerce and industry are the branches and leaves. If anything happens to the root of this tree, the leaves fall, the branches break and the tree dies. So public prosperity is the thing we are interested in, and its foundation—agriculture.

Gyratory Crushers as Primary Breakers

By W. J. Roberts
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THE selection of the type of crusher to be used in a quarry depends on many factors. Those of most importance being the size of the rock, the quantity per hour, the characteristics of the stone and the size of the product required.

The gyratory crusher can now be built to handle any size rock that is encountered in quarries and that can be successfully handled with steam shovels of the largest size. The special advantage of the gyratory crusher is the large area of the two receiving openings. If one should become clogged, the other is always open to receive stone so that crushing can be continued while the choked opening is released. This feature does not obtain with the jaw crusher, it having a single opening. The large opening has a further advantage of providing more storage capacity for the quarry rock on the feed floor or hopper as it is dumped from large cars because the mass of stone does not have to be concentrated or spouted into a comparatively small opening such as exists with the jaw crusher. The spouting with a gyratory crusher is in a direct line, usually at right angles from quarry car track. With a jaw crusher, however, the spouting is not only at right angles but parallel and in opposite direction at the ends of the car, all of which tends to choke the opening because of the bridging action of the three streams of rock converging into the jaw opening.

A gyratory crusher having the same width of opening as a jaw crusher has three times the receiving opening and three times the capacity of the jaw machine, so that the quantity that can be crushed is at least three times as great as with the jaw crusher. The gyratory crusher may be operated at higher speed than a jaw crusher of the same width of opening because there are no reciprocating parts to limit this speed. This also in a measure increases the capacity of this type of machine. It provides a reserve capacity to take care of future extensions in the plant without the addition of crushing machinery.

Operates at Any Speed

The jaw crusher depends on speed and flywheel action to keep the motion constant, due to its being a reciprocating motion, whereas the gyratory crusher can be operated at any speed desired. Therefore, the gyratory crusher with a large receiving opening can be used to handle large pieces for economy in quarry operations, and the crusher speeded low to keep the capacity down as desired and to prevent flooding the balance of the crushing plant equipment. The gyratory crusher having a constant movement and crushing only at one point on the circumference of the crushing head, requires no flywheel to keep up the motion, and therefore all gyratory crushers are fitted with plain pulleys, or rope sheaves, as the case may be.

The crushing surfaces in the gyratory crusher are curved. This provides a better crushing surface for dealing with slabby or heavy stratified rock. The peculiar eccentric movement of the head is also of advantage when crushing boulders, because they roll into pinching position more gradually than in the jaw crusher.

The jaw crusher strikes a direct or smashing blow at every piece of rock exposed to crushing action as the swing jaw moves forward, while the gyratory crusher head can adjust itself to the rock exposed to crushing action, as the crushing head is free to turn in either direction, which has a marked tendency to cut down the peak load on the power.

The size of the product can be made smaller in a gyratory crusher than in the jaw. This is due to the curved crushing surfaces and the continuous breaking action. In a jaw crusher the breaking is intermittent, probably not taking place more than three-eighths of the time, and the machine, therefore, subject to greater stresses and more severe shocks than the gyratory.

Reduction Ratios

The size of the product produced by a crusher varies in the same machine, because it is governed by the hardness of the rock and the shape of the stone, also its tendency to pack or gum the crusher. The ratio of the product to the size of the receiving opening has been called the ratio of reduction and in most gyratories this ratio varies between one to four and one to six. In the modern gyratory crushers it has been increased under favorable conditions to one to ten. In other words, the size of the product is one-tenth the width of the feed opening. This ratio is much greater than is possible with jaw crushers.

The first cost, upkeep, operating expenses and power consumption of a gyratory crusher are less per ton of rock handled than in a jaw crusher because of the facts enumerated above. This is more especially true when crushing fine, because the jaw crusher is incapable of breaking small and tends to pack if fine crushing is attempted.

When it is necessary to make the inevitable repairs, the modern gyratory crusher is just as accessible as the jaw crusher and the time required to make the repairs is no greater than in the jaw crushers. It is advisable to keep spare parts on hand and the cost of these for the gyratory crusher is no greater than for the jaw when considering the tonnage handled.

Improvements in Recent Designs

The first crushers were of the jaw type and it took about 30 years to introduce the gyratory machine. It has now been thoroughly established, so that some users would not think of considering a jaw crusher even if the jaw crusher would be more suitable for the work required. The development of the gyratory crusher has been more rapid than that of the jaw. It was delayed to some extent by the lack of strength in the design. This has been corrected in the modern machine and the gyratory type machines can be furnished to deal with any rock.

The modern gyratory crusher is entirely different, stronger, more reliable, accessible and in fact in every detail it is superior to the earlier models. The volume of material handled and the ratio reduction have been increased and the breakdowns have been reduced so that it is impossible to compare the work done with a modern machine with that performed 10 years ago. Lubrication was not given very much attention in the old days. Now it is of a paramount importance and the modern machine is thoroughly lubricated in a most approved manner to operate long periods of time under the most severe service.

Each Crushing Plant Problem Must Be Studied

These desirable results have been obtained by providing the gyratory crusher with an unyielding spider or upper bearing for the shaft, an absolutely reliable suspension device, an unbreakable and extremely rigid shaft, a perfect seal for the eccentric bearing to exclude grit from the working parts, a reliable and efficient circulating device for the lubricant and by the use of accurately cut steel gears running in oil.

The above outlined improvements have made it possible to build gyratory crushers with enormous capacities, and they are now built with openings as large as 60 in. by 210 in. and with capacity up to 4000 tons per hour. In one instance, 1,133,000 tons passed through one gyratory crusher in 26 working days of 20 hours per day. This gives an average of 2200 tons per hour, every pound of which was weighed as it was loaded out.

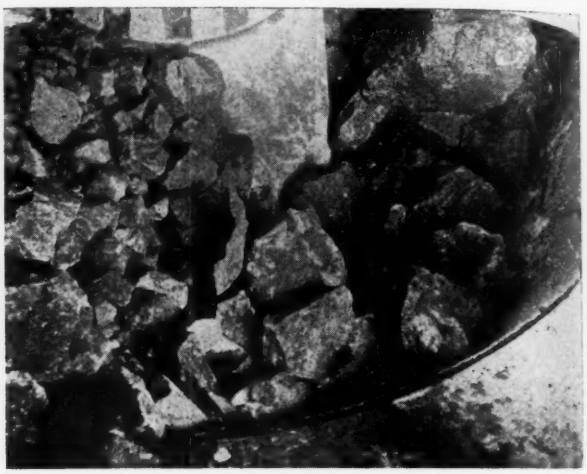
In conclusion, the gyratory crusher is adapted practically for all crushing condi-

tions, but it is necessary for the builder of the machine to be thoroughly familiar with all conditions in which the crusher is to operate in order to supply a suitable machine which will be economical to operate, reliable and highly satisfactory.

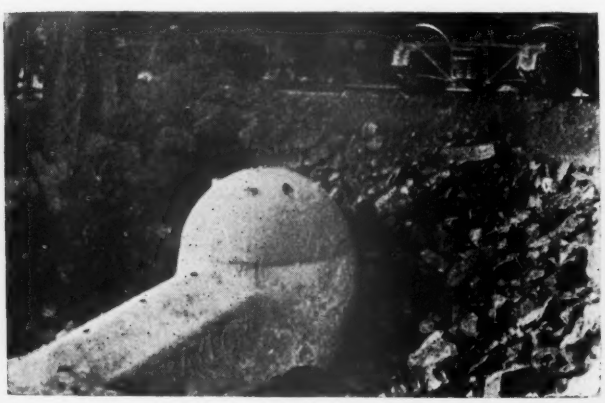
It is necessary for the builder of the crusher to know all of the facts which enter into the crushing problem. As no two of them are the same, too much attention in studying the conditions cannot be given any one case. With proper study, all the crushing problems have been solved satisfactorily, resulting in economical and reliable crushing plants.

Largest Gyratory Crusher Installation in the World—A 60-in. Traylor "Bull-Dog" Crusher

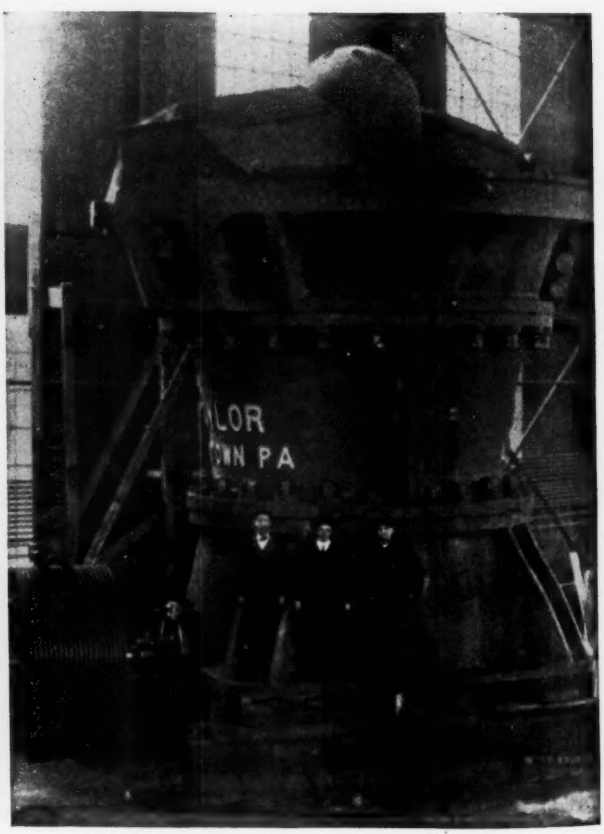
Showing comparative size of a workman and the yoke of a 60-in. gyratory crusher



Looking down into the mouth of a 60-in. gyratory crusher working on limestone for flux; about 1,250,000 tons of stone went through this crusher in 26 working days of 20 hours each



Showing comparative size of crusher head and large-size four-wheel-truck dumping quarry cars



Crusher hopper is the full length of big eight-wheel quarry cars

A 60-in. gyratory crusher assembled in shop before shipment to crushing plant

Considerations Affecting he Design of Revolving Screens for Crushed Limestone

By C. B. Magrath
Consumers Co., Chicago, Ill.

SOME little time ago it became necessary to change the screening arrangements at one of our crusher buildings. Before doing so an investigation was made of the formula and tests available on the design of screens; and it was found that there had not been a great deal of data published. The following notes are not in any way suggested as a complete treatise on revolving screens, and some of the factors discussed may be given more or less prominence than they deserve. This fact can only be ascertained by making much more complete tests than have been carried out so far.

The matter of screening is becoming of greater importance each year on account of the architects' demands being more rigid. This is particularly the case in the Chicago market.

The demand for stone through a 1-in. ring with a minimum of screenings or dust has forced us to discontinue the use of the revolving screen entirely for making separations of less than ⅞ in. Our product now goes from the ⅞-in. perforations of the revolving screens to vibrating screens, such as the "Hummer" and "Universal," where the dust and ¼-in. is shaken out. Accordingly, the information below is of doubtful value when considering the action of a revolving screen for sizes less than ⅞ in.

In any discussion of screening we can get no measure of the effect of clay and moisture, but we know that both these have less effect on sizes larger than ⅞ in. than when trying to separate screenings or dust out of the ⅞-in. On sizes larger than 1⅝-in. ring, clay and moisture have only a slight effect unless the percentage is very great.

Screening Efficiency

Before going into the question of screen capacities, the matter of screening efficiency must be discussed, because the desired efficiency has a marked effect on capacity.

Screening efficiency is the ratio of the difference between the tonnage through the perforations and the tonnage of that size taken into the screen in the feed. For example, suppose the feed to a screen contains 25 tons per hour, which is minus 1 in.,* and only 20 tons per hour go through the 1-in. perforations—then five tons per hour of that stone which could go through the 1-in. perforations is carried over in the tailings, and the efficiency of the 1-in. perforations is measured by $\frac{25-5}{25}$ or 80 per cent.

*Less than 1 in. in size.

To change this definition of efficiency into terms of the screen analysis of the feed and rejections it becomes:

Efficiency of the perforations whose holes are d inches in diameter $= \frac{100(A-B)}{A(100-B)}$.

Where A is the percentage of material fed to the screen which would go through a hole d inches in diameter

B is the percentage of throughs, as above, in the tailings.

In dealing with a screen of more than one size of perforations—that is, the usual type used for stone screens, the percentage of throughs in the tailings or rejections (B in the above formula) must be calculated as follows:

Suppose the feed to the screen be 100 tons per hour, and that the perforations be 1-in., 2½-in., and 4-in. Assume that the screen analysis of the feed is 20 per cent minus 1 in., 30 per cent between 1 in. and 2½ in., and 30 per cent between 2½ and 4 in., and 20 per cent over 4 in. The amount of material carried through the 2½-in. perforations, which is minus 1 in., is a measure of the efficiency of the 1-in. perforations. Except in cases of very low efficiency, little of this 1-in. material will get over into the 4-in. sections. If it is found that the material through the 2½-in. perforations runs 15 per cent minus 1 in., B in the above formula

$= \frac{15\times30}{30+30+20} = 5.6$ per cent, and the efficiency of the 1-in. perforations of this screen

$= \frac{100(20-5.6)}{20(100-5.6)} = 76$ per cent.

Screen Design

The difficulty in discovering the relationship underlying the design of a revolving screen from a series of tests is that there are so many variables. For any screen of a certain length, diameter, peripheral speed and perforations in the screen plate, the performance is effected by the rate of speed in tons per hour, the screen analysis of the feed, the shape of the stone as fractured by the crusher, and the clay and moisture present.

The first thing to decide in designing a screen is the proper diameter. The considerations affecting the proper diameter is the size of the largest pieces of rock in the feed to the screen, the volume of the feed in tons per hour, and the screening efficiency required.

The thickness of the mass of stone in the upper part of any screen has a direct ratio to the size of the largest pieces in the feed. This is very clearly brought out by feeding a small screen with material, the largest pieces of which are 2-in. ring. If the crusher is opened up so that the largest pieces in the feed run up to 4 in., it will be found that the capacity of the screen is greater in the latter case than in the former. That is to say, the screening efficiency is greater in the case of the larger stone if the volume of the feed is the same in both cases. If it is attempted to put through a large volume of feed in the first case the mass in the screen will tend to "roll up," and cut down the screening efficiency very greatly.

This relationship of maximum thickness of mass in the screen and maximum ring size of feed has a very definite bearing on the screen diameter. For a fixed angle of inclination this maximum thickness of mass is a measure of the capacity of the screen. As will appear below, there is also a very definite relationship between the diameter and the maximum capacity of the screen.

In this discussion maximum ring size has been used, as it has been found that it is comparatively easy to determine. In examining the discharge from a crusher to determine the maximum ring size of the discharge, an average should be taken of about a dozen of the largest pieces of rock. This procedure is not quite as accurate as actually making an analysis of the discharge of the crusher and basing calculations on the ring diameter that will pass 85 per cent of the entire discharge.

In this connection it may be of interest to note that the discharge from gyratory crushers, in most cases, results in a product such that the percentage of the different sizes is practically a direct ratio of those sizes. The accompanying table makes this clear. This table is used in arriving at the necessary length of screen sections.

Maximum ring size, in.	Percentages of total: Minus 1 in.	From 1 to 1½ in.	From 1½ to 2½ in.	From 2½ to 4 in.	More than 4 in.
3	34	16	33	17	....
4	25	13	25	37	....
5	20	10	20	30	20
6	17	8	17	25	33
7	15	6	14	22	43
8	13	5	12	20	50

From theoretical considerations, by making several liberal assumptions, the capacity of a screen $= C\times D\sqrt{C_1 \cdot D \cdot t + t^2}$

Where C is a coefficient

C_1 is a constant

D is the diameter of the screen and

t is the maximum thickness of the mass in the upper portion of the screen.

If we are to limit this thickness of mass, t, to a certain ratio of the maximum ring size in the feed, our formula then becomes:

Feed to the screen $= CD\sqrt{C_2DR+R^2}$

Where C is a coefficient

C_2 is a constant

D is the diameter of screen in inches, and

R the maximum ring size of the feed in inches.

As R is very small in comparison with D, for all practical purposes we can say

Capacity = Coefficient $\times D\sqrt{DR}$

The value of this coefficient depends upon the screening efficiency required.

Screen Capacities

The above formula is derived on the assumption that the path of any particle as traced out on the screen cylinder is a helix, which is probably almost correct. The properties of this helix are that the length of the path of a piece of stone (too large to go through the perforations) is independent of the diameter of the cylinder, but varies directly as the length of the cylinder. The length of the pitch of the helix (which is a measure of the capacity of the screen) is a direct multiple of the diameter of the cylinder and is independent of its length. The usual rule as found by actual practice is to set the axis of the screen at an angle of from 5 to 6 deg. with the horizontal, which corresponds with a fall of 1¼ and 1½ in. per foot, respectively. For an angle of 7 deg. the pitch of the helix is 0.55 times the diameter of the screen, and the length of travel of a piece of stone (too large to go through the perforations) is 5.8 times the length of the screen.

It will be noticed that the above formula says nothing about the length of the screen, as in arriving at the proper diameter the length need not be considered unless the angle of inclination be altered. If this angle be decreased, the capacity of the screen is decreased, because the pitch of the helix is cut down.

Screen Lengths and Efficiencies

The efficiency of two screens with equal diameters and feeds is dependent upon the length of the screens, but the relationship is by no means simple. The table below shows how the length varies with the efficiency, the length being expressed as multiples of the length necessary to give 50 per cent screening efficiency. That is to say, if we need a screen section 4 ft. long to get 50 per cent efficiency, to get 80 per cent efficiency we will multiply 4 by the coefficient opposite 80 in the table and the result is the length of section necessary to give 80 per cent efficiency under similar conditions. The standard was not selected as 50 per cent because we considered that a standard for screening efficiency but rather that it results in a more uniform table.

Efficiency of screen per cent	Multiple of length per cent
50	1.0
60	1.3
70	1.6
80	2.0
90	3.3
95	6.1

This table indicates that we need a 30 per cent increase in length of screen section to increase the efficiency from 50 to 60 per cent, whereas, an increase of 65 per cent in screen length is needed to increase the efficiency from 80 to 90 per cent.

This table also makes it very apparent that for a definite diameter and volume of feed, high screening efficiency is only gained at the expense of an impracticable length—or else the volume of the feed must be cut down, as this has a marked effect on efficiency. For a very slight volume passing over the screen we can very well expect practically 100 per cent efficiency, whereas, on the other hand, we can load the screen up to a point where in the extreme case the mass of material in the screen becomes so great as to prevent the material from rolling; in other words, overload the screen so heavily that it blocks up and its efficiency is then almost zero.

One method of obtaining high screening efficiency is to pass the sized products from the revolving screen to vibrators which will shake out the excess of small sizes. In one of our plants where the screening area of the revolving screens is inadequate, we pass the 1⅝x1-in. material from the revolving screens over a vibrator with very good results.

However, it may not always be desirable to do this on account of the excess cost or lack of sufficient headroom; therefore, the required efficiency must be considered in arriving at the proper diameter of screen for any given tonnage to be screened; in other words, to gain high efficiency the feed for a given diameter of screen is cut down. This is accomplished by varying the constant C mentioned in the above formula. Most screens in quarry-crusher buildings are working with an efficiency varying from 70 to 80 per cent. Some installations have efficiencies as low as 60 per cent, while on the other hand, one test showed an efficiency as high as 94 per cent. This latter screen was in a large plant, while running at one-third capacity.

The following table shows the variation in this coefficient C for different efficiencies, when the diameter is in inches and the capacity in tons per hour, provided that there is not an excess of moisture or clay:

Efficiency of screen per cent	Coefficient C per cent
50	.16
60	.15
70	.13
80	.12
90	.10
95	.07

The capacity of a screen for any diameter can readily be worked out for any required screen efficiency and maximum ring size of feed by using this table. Capacities are tabulated below, based on a screen efficiency of 80 per cent.

FEED TO SCREEN IN TONS PER HOUR, TO GIVE ABOUT 80 PER CENT SCREENING EFFICIENCY

Maximum ring size, in.	Diameter of screen 36 in. tons	40 in. tons	48 in. tons	60 in. tons	72 in. tons
6	....	....	98	137	180
5	....	68	90	124	156
4	52	61	80	112	147
3	45	52	69	97	127
2	37	43	....	....	....

In estimating the feed to a screen the rejections must be included if they are recrushed and returned to the screen.

Screen Loading

Any formula for the necessary length of a section of a screen for a required efficiency must be a function of the volume of material entering that section of the screen, because the density of loading varies throughout the entire length of the screen. To illustrate this: If a screen be 24 ft. long and have a section 12 ft. long with 1-in. perforations, another section 8 ft. long with 1½-in. perforations and the last section 4 ft. long with 2½-in. perforations, it is quite possible that the efficiency of each screen section will be about the same. (Whether or not this was true would depend upon the screen analysis of the feed to the screen.) The reason for this is that the section with 2½-in. holes is handling much less material than the section with 1-in. holes. The relationship between length of screen section necessary for various amounts of feed to that section when all other factors are constant is measured by the square root of the feed to that section. This is purely empirical and on further investigation it may develop that the square root of the feed is not sufficient a variation in necessary length for changes in the feed.

Also in considering the factors affecting the proper length of a revolving screen or a section thereof, we must take into consideration what portion of the volume passing over the screen or the section thereof we wish to remove. That is to say, suppose we are feeding a screen with 100 tons per hour, and that this feed is all minus 3½ in. Assume that 30 per cent of this feed, or 30 tons per hour, is all minus 1 in. and that 57 per cent, or 57 tons per hour, is minus 2 in. To make an initial separation in both cases and with equal screen efficiency we would not need as great a length of section in the second case as in the first. Consider the extreme case for a minute. On this same screen let us put sections for the initial separation, the perforations of which are 3½ in. or the same as the maximum ring size of the feed. Almost the entire volume of the feed would go through the perforations within a couple of feet of the top of the screen.

As this percentage of volume to be removed by the screen section increases, the length of the section necessary to make the separation decreases. The extreme case is when the perforations in the plate are the same diameter as the maximum ring size of the feed. In this case practically the entire feed will go through the perforations within a couple of feet of the top of the screen. Obviously, as the ratio of the diameter of screen perforations to maximum ring size of feed decreases, the length of the screen section necessary will increase. Relative volumes are not measured exactly by the ratio of ring sizes, especially after the material has passed over the first section of the screen and has had the smaller sizes removed. However, there is so little data available on

the effect of relative volumes that it is unwise to introduce too much refinement, as it is somewhat simpler to deal with ring sizes and diameter of perforations.

From the information available, it appears that for screens of the same size and the same volume and size of feed, the necessary length of screen section to give the same screening efficiency for different sizes of perforations

$$\text{varies as } \sqrt{\frac{Rr}{R_1} + 2}$$

where Rr is the maximum ring size of the feed, R_1 is the diameter of the perforations in the section of screen under discussion.

Screen Capacity and Percentage of Screen Openings

There is another factor which should be considered and that is, the percentage of openings in the screen plate. A wire mesh will give greater screening capacity than a perforated plate. This is certainly true for the smaller sizes and it is probably true for the larger sizes. The following table supplied by a perforated plate manufacturer shows the openings as a percentage of the total area:

Diameter of hole in.	Openings of total area per cent
1	40
1½	45
1¾	48
2	53
2½	53

Wire mesh with a 1-in. opening and 0.207 wire has 70 per cent of its area as openings.

As the work done by the screen plate is measured by the perforations in the plate, to get an estimate of the necessary length we may say that the necessary length varies inversely as the percentage of openings in the screen plate. A square opening produces a product which has a screen analysis equivalent to that produced by round holes about 10 per cent larger in diameter.

By combining the above relationships in the nature of a formula, we get the following:

$$L = 10\frac{\sqrt{F}}{O}\left(\sqrt{\frac{Rr}{R_1}} + 2\right)$$

Where L equals the length of the screen section under discussion in feet

F the volume of the feed to the section of the screen in tons per hour

O percentage of openings in screen plate

Rr is the ring size of the largest pieces in the feed to the section in inches

R_1 is the diameter of the perforations in the section in inches.

The constant 10 seems to give fairly accurate results for screens whose capacities are in accordance with the table of capacities above. The feed F is not the entire feed to the screen except for the first section, or upper series of perforations.

Dust Jackets

The relationship expressed above probably will be of no value in determining the size or length of dust jackets. Our plants do not use them, and therefore I have no data on the same. As pointed out above, we find vibrators more efficient for that purpose and we find it necessary to use every foot of length of our revolving screens to give the necessary screening efficiency of the larger size.

Speed of Rotation

This relationship assumes that the screen is rotated at the correct peripheral speed. The action of the stone should be a rolling one, the stone being carried slightly more than 45 deg. in the direction of rotation. It rolls back and goes about 10 deg. on the other side of a vertical line through the center. If, on the other hand, the mass of stone slides through the screen, poor work will result. A rolling motion can be obtained by changing the screen speed, which should be about 200 ft. per minute.

Examples of Formula Applied

The results obtained by this formula are illustrated below: A screen 36 in. in diameter is fed with 45 tons per hour, all of which passes a 3-in. ring. The perforations in this screen are 1-in., 1½-in., and 2½-in., and the necessary lengths are 7 ft. for the 1-in. perforations, 5 ft. for the 1½-in. perforations and 3 ft. for the 2½-in. perforations. The screen then should be 15 ft. long.

A screen 48 in. in diameter is fed with 100 tons per hour, all of which feed will pass a 6-in. ring. If the perforations in the screen are 1-in., 1½-in., and 2½-in., the necessary lengths are 10 ft. for the 1-in. perforations, 8 ft. for the 1½-in. perforations, and 6 ft. for the 2½-in. perforations. The screen then would be 24 ft. long. In this case if the feed was all minus 4 in. the lengths of the 1-in. perforations would be 10 ft., for the 1½-in. perforations 7 ft., and for the 2½-in. perforations 5 ft., or a total length of screen of 22 ft.

A screen 60 in. in diameter is fed with 135 tons per hour, all of which passes a 6-in. ring. The perforations required are 1-in., 2½-in., and 4-in. The necessary lengths are 12 ft. for the 1-in. section, 7 ft. for the 2½-in. section, and 5 ft. for the 4-in. section. The total length of the screen is therefore 24 ft.

The great difficulty in getting any data of value in connection with screening is the cost. Unless the test is most complete, it is of little value for the purpose of discovering any relationship between the variables. We made tests on 12 pairs of revolving screens under different conditions, but unfortunately when we came to analyze these, we found errors which rendered some of the tests useless. It is therefore quite apparent that no hard and fast rules can be laid down on the basis of these tests, but it is hoped that with further data, which may become available from time to time, the above can be checked and modified where necessary.

Membership of the Association Up to March 3

THE National Crushed Stone Association now has more members than ever before. The following is the list of members and the number of $25 memberships each firm has taken up to and including March 3:

	No. of Memberships
W. W. Boxley & Co., Roanoke, Va.	6
Connecticut Quarries Co., New Haven, Conn.	5
Wisconsin Granite Co., Chicago	5
Ohio Marble Co., Piqua, O.	5
Rock Cut Stone Co., Syracuse, N. Y.	5
New Haven Trap Rock Co., New Haven	5
Marble Cliff Quarries Co., Columbus, O.	5
Kelley Island Lime & Transport Co., Cleveland	5
John T. Dyer Quarry Co., Norristown, Pa.	4
Toledo Stone & Glass Sand Co., Toledo	4
Canada Crushed Stone Corp., Dundas, Ont.	4
Mesabi Iron Co., Babbitt, Minn.	4
Buffalo Crushed Stone Co., Buffalo, N. Y.	4
The Weston & Brooker Co., Columbia, S. C.	4
Edward Hely Stone Co., Cape Girardeau, Mo.	4
Buffalo Cement Co., Ltd., Buffalo, N. Y.	3
A. N. Spencer, San Antonio, Tex.	2
Universal Granite Quarries Co., Chicago	2
Elmhurst Chicago Stone Co., Elmhurst, Ill.	2
Davis Bros. Stone Co., Lannon, Wis.	2
Water Street Trap Rock Co., Water Street, Pa.	2
Trap Rock Co., Minneapolis, Minn.	2
Stringtown Crushed Rock Co., McAlester, Okla.	2
A. R. Voss Co., New Ulm, Minn.	2
Goher Stone Co., Minneapolis, Minn.	2
Liberty Lime & Stone Co., Rocky Point, Va.	2
Morris County Crushed Stone Co., Morristown, Pa.	2
Lake Shore Stone Co., Milwaukee, Wis.	2
R. B. Tyler Co., Louisville, Ky.	2
Bound Brook Crushed Stone Co., Bound Brook, N. J.	2
Gager Lime & Mfg. Co., Chattanooga, Tenn.	2
Waukesha Lime & Stone Co., Waukesha, Wis.	2
Norton Stone & Lime Corp., Albany, N. Y.	2
Quartzite Quarries Co., Luverne, Minn.	2
Granite Rock Co., Watsonville, Calif.	2
Van Camp Stone Co., Cincinnati, O.	2
Greenville Stone & Gravel Co., Memphis, Tenn.	2
Thomas McCroskey, Knoxville, Tenn.	2
Columbia Quarry Co., St. Louis, Mo.	2
American Lime & Stone Co., Bellefonte, Pa.	2
Linwood Cement Co., Davenport, Ia.	2
Chickamauga Quarry & Const. Co., Chattanooga	2
Wickwire Spencer Steel Corp., Buffalo	2
Dolomite Products Co., Rochester, N. Y.	1
Allwood Lime Co., Manitowoc, Wis.	1
John Wunder, Minneapolis, Minn.	1
Mayville White Lime Works, Mayville, Wis.	1
C. C. Beam, Melvin, O.	1
Commonwealth Quarry Co., Summit, N. J.	1
O. H. Binns, Logansport, Ind.	1
Chief Consolidated Mining Co., Salt Lake City.	1
Texas Stone Products Co., Dallas	1

Associate Members

The following is a list of associate members at $50 per year:

The Osgood Co., Marion, O.
Sanderson-Cyclone Drill Co., Orrville, O.
Robins Conveyor Belt Co., New York City.
General Explosives Co., Chicago.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Rock Products, Chicago.
Pit & Quarry, Chicago.
Grasselli Powder Co., Cleveland, O.
Marion Steam Shovel Co., Marion, O.
Trojan Powder Co., Allentown, Pa.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
E. I. du Pont de Nemours & Co., Wilmington, Del.
C. B. Buchanan Co., New York City.
Chalmers & Williams Co., New York City.
Atlas Powder Co., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.
Buffalo Wire Works, Buffalo, N. Y.
Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Smith Engineering Co., Milwaukee, Wis.
American Manganese Steel Co., Chicago Heights, Ill.

The Principles of Hydraulic Separation

By Edmund Shaw
Consulting Engineer, Chicago

ALL washing is, in a sense, hydraulic separation, but we usually limit the term to the separation of material into two or more products each of which has a limiting size. It is a handy method because it fits in so well with washing to remove clay or dirt. The same water and the same apparatus can be made to serve both purposes. We can design the apparatus so that the clay alone will be taken out, or the clay and the fine sand up to 100 mesh, or 50 mesh, or any other size that we please, up to the limit of good work in this way.

The limit of good work in hydraulic separation depends on the nature of the material. If it is composed of well-rounded grains, we can carry hydraulic separation up to ¼ in. and get good results. But if the material contains a lot of flat and scaley pieces, such as are usually found in crusher sand, we cannot carry it so far. Perhaps ⅛ in. might be said to be the limit of good work in such a case.

There are three principal ways in which we may apply a current of water to separate grains into different sizes. These are called: a top or surface current, a rising current, and a special form of rising current called hydraulic water. Many devices employ a combination of two of these currents.

The surface current is very often employed because it fits in well with other purposes. It can be applied to a bin in which the washed material is to be stored, after the separation has been made, with the least loss of headroom, and while it is not especially good for making a close separation, this advantage is so great that probably it will always be used, especially in handling the finer-mesh sizes.

Fig. 1 shows the simplest form of a top current separator. The water which carries the sand enters at the left-hand and flows across the top of the box directly to the overflow at the right-hand end. Grains of sand in the current are falling through it all the time that the current carries them along. Those which can fall fast enough will fall out of the current altogether and be caught in the box, while the others will be carried out with the overflow, along with any clay and mud that may be present.

To design such a box, we must know the speed of the current and the rate of fall of the different sizes of the grains of sand. The speed of the current we can make anything that we please, if the box is made wide enough to start with, for we can put in side partitions to narrow it up and make it flow faster until we get the velocity that we want. These partitions do not have to extend to the bottom of the box; they only need to go as far as the current will go, and that is usually less than a foot. To be sure, we may make them 18 in. deep.

The rate of fall of grains of different sizes of sand has been determined by thousands of experiments and many tables have been published. The accompanying table is

Edmund Shaw.

one that I have prepared from a number of tests, but, like all such tables, it is good only with the particular material with which the tests were made. However, that does not hinder us from using it as a basis in designing, because the falling rates of various sands do not differ so very much, provided the materials are of about the same specific gravity.

And then, as we shall see, we can always so design our apparatus that it will be adjustable, so that if we do not get what we want at the first trial, we can get it a little later by changing a removable partition.

TABLE OF FALLING RATES

Size of grain—Through mesh	Size of grain—On mesh	Falling rate in inches per second
8	10	6.6
10	14	5.1
14	20	3.9
20	40	2.8
40	60	1.5
60	80	1.0
80	100	0.7

As the easiest way to show how to use this table is to give an example, I will suppose that we are to design a box which is to throw out everything finer than 100 mesh. We will assume that the velocity of the current is 2 ft. per second, and it is fair to assume this because we may make it that by putting in partitions. Then we want to know how long to make it in order that the 100 mesh and finer will be thrown out.

We see that 100-mesh material has a falling rate of 0.7 in. per second, which means that it will fall a foot in 17 sec. (practically), and hence we want the box as long as the current will be in flowing for 17 sec. The velocity being 2 ft. per second, the box will have to be twice 17, or 34 ft., to give the grains coarser than 100 mesh the time to settle, and to throw out the grains finer than 100 mesh.

If this box is longer than is desired we can arrive at the same result by changing the velocity of the current. We can set our partitions farther apart, so that the velocity will be only 1 ft. per second, in which case we would have to make the box only one-half as long, or 17 ft.

So, by varying either the length of the box or the width of the space through which it flows, we may get any results that we please, up to the limits of efficient work. But the use of such a top current as has been discussed is not always satisfactory. For one thing, the front end of the box fills up very quickly, leaving the rest of the box with only a coating of fine sand on the bottom. Another disadvantage is that an eddy current forms where the current strikes the partition under the overflow; this drags down a lot of fine sand which should go out with the overflow. A third disadvantage is that the current passing over so large a space of dead water induces the settling of a considerable amount of clay, an effect due to the friction of the moving water upon the still water below.

The rising current offers a more certain means of making the separation that we want. A typical form of the device is shown in Fig. 2, which represents a section through the device. The current enters in the central channel and passes down and under the partitions and then rises on the other side of the partitions to the overflow. Any sand which has a falling rate less than the rising rate of the current is bound to be carried out with the current, and any sand which has a falling rate greater than the rising rate of the current is bound to stay in the box. Hence the separation is a definite one. In an experimental way, and using laboratory apparatus, one may make a test over and over again and always obtain the same results, which is hardly possible with a top-current device.

Calculating the Velocity

We may calculate the velocity of this rising current by knowing the quantity of water with which we have to deal and dividing it by the cross-section area of the channel through which the rising current has to pass. If we have 3850 cu. in. of water a second passing (which is 1000 g.p.m.) and it rises through a channel which has 1000 sq. in. cross-section area, we know that the velocity will be 3.85 in. per second. This, as we may see from the table, is about the velocity required to raise 14 mesh. Suppose that we wanted to raise only 100-mesh particles, which have a falling rate of 0.7 in. per second. We would make the area 3850 divided by 0.7, which is 5500 sq. in. If we suppose the box to be square, we may get at the length of one side by finding the square root, which is about 72.3. In other words, the box is practically 6 ft. square.

As before, we must allow some method of adjustment, and this is easily done by putting in partitions which can be moved to make the channel for the rising current narrower. I have drawn in partitions in dotted lines. Now if we wanted to make such a box to throw out 100 mesh and finer, we would make it, not 6x6 ft., but 6x8 ft., say, and this extra foot on each side would give us the needed latitude for adjustment.

The third method of making a hydraulic separation is that of using what is called "hydraulic water," which is the term applied to water taken from another source than the feed water, and applied to the sand after a partial separation has been made by either a top current or a rising current.

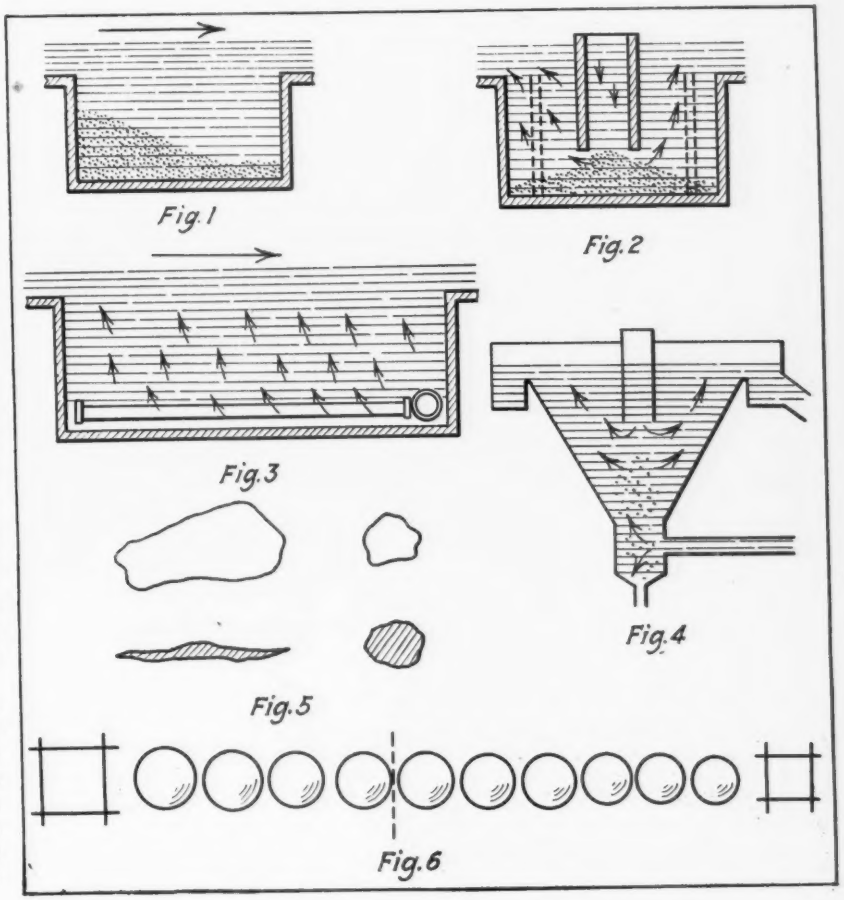
Fig. 3 shows it applied to a top current device. There is a set of pipes with small holes in the bottom of the box, and the clear water issues from these holes. This water makes an upflow of such velocity as is required, lifting such a size of sand as is wanted to be thrown out and displacing the muddy water, which would otherwise settle with the sand.

The particular form shown in this figure is a crude application of hydraulic water, but it has been often employed in practice, and the writer knows of several instances in which it has been used to make filter sand.

A set of pipes may be used in the same way to apply hydraulic water to a rising current box, but the common way to use it with a rising current is that shown in Fig. 4. Instead of a box, a cone is used, the discharge being from the apex of the cone. Above the apex is a water chamber, to which the clear water is admitted, and the pressure of the water is strong enough so that not all of it flows out of the discharge orifice; a part of it has to rise and form a rising current in the lower part of the cone. Any too fine grains which are not carried to the overflow by the first rising current formed by the feed water are carried up by the rising current of the hydraulic water, and eventually find their way to the overflow.

The "Hydraulic Classifier"

This is a very old device, and the books call it a "hydraulic classifier." Today it is not much used in the ore dressing field, in which it was developed, but it is coming into use in the sand-washing field, because it is particularly adapted to the work in this field, and it fits in well with the general design of washing plants.



These drawings show the principles of hydraulic separation

While it is perhaps a little outside of the province of this paper, one may call attention to the fact that the hydraulic current offers the most economical method of giving a second wash, or rinse, to sand which is still accompanied by clay after the first washing. The rising current, passing upward between the grains of sand, completely displaces the dirty water without mixing with the dirty water in more than a very slight degree.

In this way the water to be used is kept at the minimum, which is a quantity just sufficient to fill the voids of the sand, with perhaps 5 per cent added for dilution. Machines of the writer's design employing hydraulic water have been used in washing building sand and the fine sand from phosphate rock, in plants handling up to 1000 tons per day, and the consumption of water for giving the second wash in this way has been found to agree with the statement just made.

In the beginning of this paper, it was said that the limit of good work in separating such material as crusher sand was perhaps at ⅛ in. This statement ought to be given some explanation. The method of hydraulic separation is very exact. The same grain always falls at the same rate, and consequently the same rising current will always lift the same grain. But the method takes notice of the *weight* of the grain and not its dimensions. In Fig. 5 are drawn two grains, a flat scale and a round grain. Both weigh the same and the current would put them into the same classification, but the flat grain is several screen sizes larger than the rounded grain.

We test all separations by screens, and hence we would consider the inclusion of these two grains in the same product as poor work, but from the point of view of the rising current it would be considered very exact work. These differences between weight and area are not so common or so

noticeable in the fine mesh sizes as they are in the coarse sizes, so that *apparently* hydraulic separation does better work on the fine sizes.

As it takes notice of weight and not of dimension, the rising current will even separate grains of the same shape in a different manner from that of a screen. In Fig. 6 is shown a series of round grains, all of which lie in the same screen size—that is, they pass through one screen of a series and are retained on the next, the screens chosen being on the Tyler Standard system. The proportion between the greatest and smallest diameters of these grains is as 1 is to 1.4, but the proportion of weight is as 1 is to 2.8. A carefully made rising-current apparatus, such as is used in laboratory work, would split such grains into 10 different sizes. If a current was set to split them at the average of these sizes, it would split them where the dotted line is drawn, which is a very different separation from that which is made by the screen.

One of the reasons why hydraulic separation has sometimes proved unsatisfactory in practice is that the principle of separation which has just been explained was not understood. A more common reason is, however, that the conditions under which it was used were not adapted to the method.

It has just been explained that the rising current is most sensitive to differences in the weight of the grain, which is the same thing as saying that the grain is very sensitive to slight changes in the rising velocity of the current. So if good work is wanted, the first requisite is an absolutely uniform current, and this can only be obtained by having a definite quantity of water flowing through a channel of a definite size.

It is by no means impossible to obtain this in a commercial plant, but usually it is neglected because it is thought that the work will be good enough without putting in the regulating tanks which are necessary to secure it. A reasonably even feed of the solids is also necessary for good work, but the necessary feeders to secure this are usually omitted, and the device is asked to deal with 5 tons in 1 min. and 50 tons in the next. The failure to provide the proper working conditions causes the method to fail and the method itself is condemned as impractical.

In commercial machines for applying hydraulic separation, the method itself is intimately connected with the means that are employed to discharge the separated products. You can see that this is so by considering any of the figures which have been shown here; take Fig. 2, for example. If the settled sand is being drawn off from this box, the downward flow is bound to affect the rising current by lessening it. There are many methods by which this lessening of the current may be avoided or compensated for, most of which are patented. To discuss them would take too much time, and it's enough for the purpose of this paper to say that these methods are efficient.

Storing and Reclaiming of Crushed Stone

By Gordon Smith

J. C. Buckbee Co., Consulting Engineers, Chicago

STONE storage falls under two general classifications: First, what is commonly called bin storage, and which we will define as that storage from which stone may be loaded directly into cars or trucks without the use of handling machinery other than gates and spouts; second, what is commonly called ground storage, or that from which the stone must be rehandled for loading. It is obvious that, under ordinary conditions, bin storage is economically unsuited for the excess production of a crushing plant over shipments in quiet seasons of the year; the first cost of concrete, steel or wooden bins of such size, precluding such use.

For reasons of limited time and space this article will be confined in its considerations to the second classification—ground storage—and in particular the application of various methods and means available for the stocking out and storage of the production of crushing plants in times of light demand, and the reclaiming and loading of this stored material during those periods in which the demand exceeds the plant capacity. It is apparent that but few installations and methods can be described in detail and that the factors surrounding the choice of a storage system are such as to make impractical definite statements as to what does or does not constitute the best method. A brief statement of these factors will prove the foregoing.

Considerations Governing a Storage System

In general, the following considerations will govern decisions relative to a storage system. The order in which they are set down is in no way intended to reflect their relative importance, as this will vary with individual installations:

Fig. 1—Storage system using shuttle conveyor

1. The amount of storage desirable. In order to determine this point, access should be had to the records and experience of the plant in question. From these sources should be obtained the average output for each month extending over as long a period of years as possible. The average shipments for each corresponding month should also be obtained, as well as some idea of the amount of business lost to the competitors, due to the fact that it could not be supplied.

This data will comprise the "experience" of the plant. What provision there is to be made for the future will have to depend

upon the owners' judgment, more or less based upon the "experience" factor mentioned, on the probable development of new markets and upon the normal growth of present markets. These will comprise the "expectancy" of the plant, and this is certainly of equal importance with the "experience."

Fig. 2—Storage system employing a tripper—Canada Crushed Stone Corp.

2. The effect of the proposed storage system upon the cost of production and the spread between such cost and the price at which stone may be sold. No storage system should ordinarily be considered where this spread is insufficient to allow for the cost of storage and reclaiming, and, at the same time, show a profit on the capital required to put in the storage system. It should always be borne in mind that the cost of stone loaded from the stockpile will exceed that of stone loaded from the plant bins.

3. The nature of the plant site, the extent of ground available for use as ground storage, and the trackage arrangements permissible. These items often limit the choice of equipment as well as the amount of storage that can be built. Their influence upon an installation is peculiar to that installation and is of such a variable nature as to make general remarks of no value.

4. In general, that system or method should be chosen that will best fulfill the needs of the plant, and, at the same time, give the most storage per dollar of first cost consistent with economical operation. The matter of first cost and operating cost must be very carefully balanced, with due regard to the amount of capital that may be required to put in the system and care for depreciation and maintenance, as well as actual operating charges.

5. A storage system will, if properly designed and built, accomplish many desirable results. It enables the plant to be run at or near capacity throughout the operating season, irrespective of the demand for its products. This results in lower costs per ton on account of uniform rate of production and consequent decreased overhead expense per ton. It enables a plant with a more or less fixed rate of production and sizes of stone to supply a demand that varies with the season of the year, car supply, and the weather.

Fig. 3—Storage system of the Canada Crushed Stone Corp.

A stockpile further enables the producer to continue shipments against contract, or accept orders, even though his plant may be down on account of weather conditions, for repairs, or other reason. It is a very tangible and striking evidence of the producer's ability to serve his customers and a forcible selling point in getting business, particularly to a contractor who must have material regularly. Generally speaking, a storage system will prove a profitable investment.

All of the foregoing are of vital moment in connection with a storage system and by their careful consideration and with the aid of competent engineering advice, the operator may be assured of a successful and profitable stockpile. Should any further justification of the necessity of a storage system for a crushing plant be necessary, we have only to look to the most profitable plants of the industry, both large and small. In almost every case will be found a storing system of some kind. The stockpile relieves any necessity of sacrificing material in order to move it and tends to stabilize markets.

Some Data on Storage Piles

Some general data on the quantity of stone that may be stored in a pile may be of interest. Crushed limestone in a pile will run about 92 lb. to the cubic foot, or about 22 cu. ft. to the ton. The angle of repose of such stone piled dry and clean and free from dust is about 37 deg., corresponding to a slope of 9 in 12. It is readily apparent that the capacity of a pile varies as the square of the depth when the cross-section area is triangular. For this reason it is customary to make the pile as deep as possible in order to keep the investment within reasonable bounds.

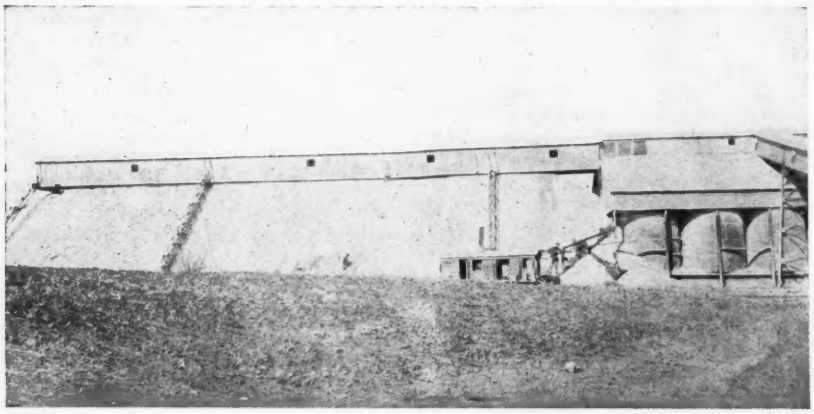


Fig. 4—Covered steel conveyor trestle over a storage pile

For most storages 40 to 60 ft. is the economical limit in height, as otherwise the pile spreads over too great an area and there is increased difficulty in reclaiming. Sixty feet is about the greatest height of conveyor gallery that is desirable from the standpoint of economical construction of bridge type and 35 to 40 ft. about the economical limit for trestles.

It is desirable, although not always permissible, so to arrange the storage system that the axis of the pile is parallel to the loading tracks under the plant bins. This will permit of tracks being placed alongside the storage pile for loading from storage and always permits the operator to help out his reclaiming system in times of stress by the use of a locomotive crane, a small shovel, or portable digging loaders.

Storage-System Qualifications

Disregarding costs and local conditions for the time, what should in general be the qualifications that make for a desirable and satisfactory storage system? What things are necessary of accomplishment in the design of a system?

First, the apparatus selected should be of a type inherently as free as possible from breakdown, and which, in case of breakdown, lends itself to ease of repair. It should preferably be simple and accessible in all parts, so that comparatively unskilled labor may be used in its operation. Reliability of apparatus is the keynote of success in the operation of crushing plants and, for that reason, apparatus should be used wherever possible that gives some evidence of weakness before an actual failure takes place. This means ease of inspection.

Second, the apparatus should be capable of easy enlargement and expansion without interrupting the operation of the original installation seriously.

Third, the operation of the storage system should be flexible—that is, it should be such that small amounts of stone per day, as well as large amounts, may be handled economically.

Fourth, it is to be desired that the system be so arranged that material of one size may be placed in storage simultaneously with the removal of another size from storage.

Fifth, it is a necessary quality of any system that the various sizes of stone produced be stored separately so that the sizing is not lost in the reclaiming; otherwise, a second screening will be necessary.

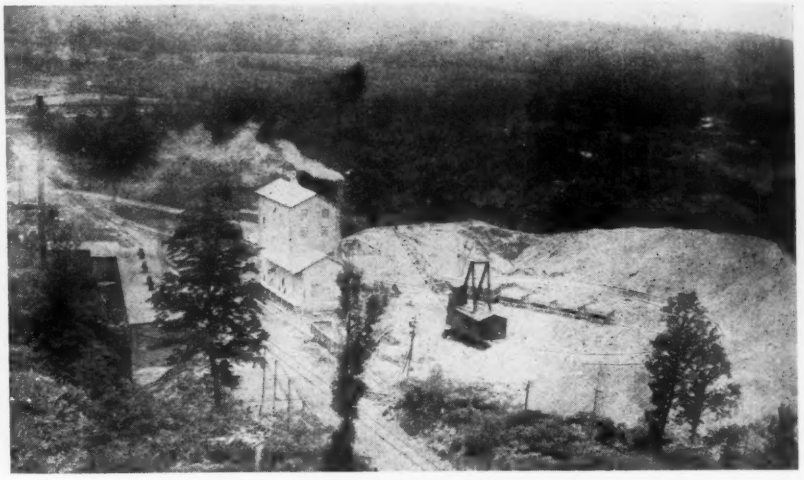


Fig. 5—Locomotive crane storage system

Fig. 6—Locomotive crane system and loading tracks

Methods for Handling Stone

There are many methods and combinations of methods for handling stone in and out of storage. The writer will endeavor now to describe briefly the more important and usual, with some remarks as to their advantages and disadvantages, and presenting cost data that may be useful both in investment and operating.

Belt conveyors suggest themselves immediately as a means of forming the pile—indeed, their use is quite general for this purpose. The usual method takes the stone from the plant or bins by a conveyor, delivering to distributing conveyors over the pile. Where the axis of the stockpile may be run in the same direction as the conveyor from the plant, this conveyor may be extended and the pile formed by a movable tripper.

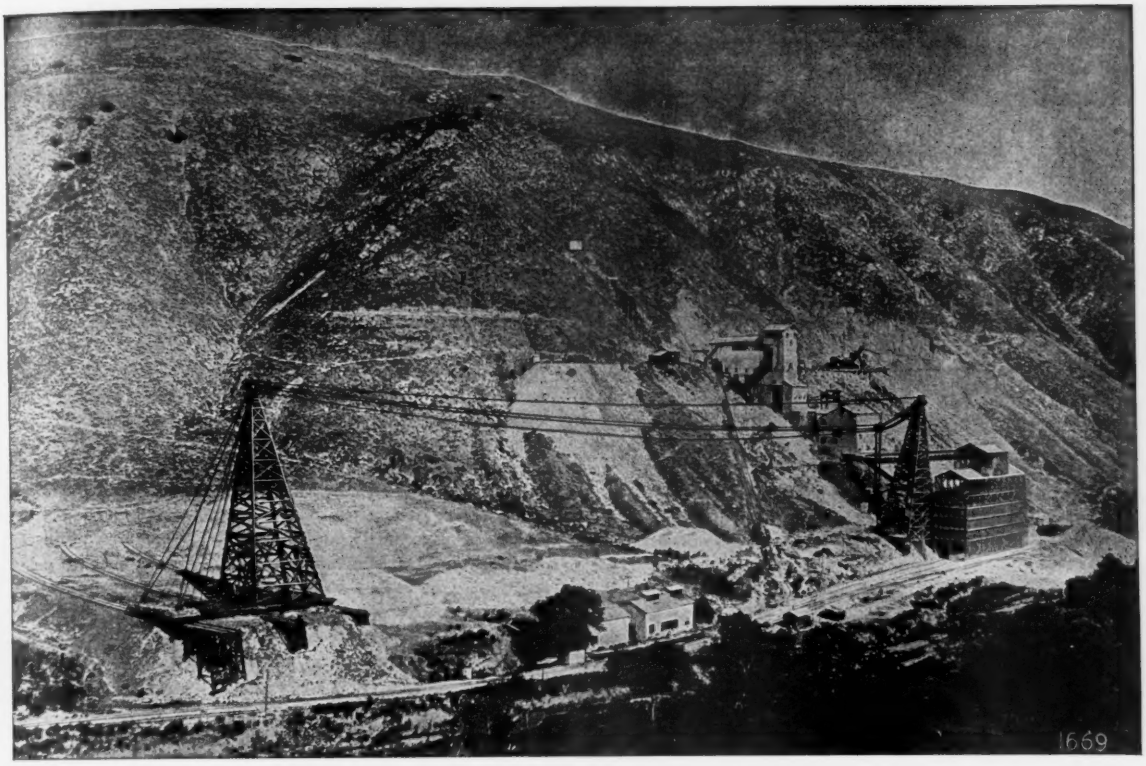


Fig. 7—General view of Blue Diamond aerial cableway

If the axis of the stockpile is to be at right angles with the feeding conveyor from the plant, the feeding conveyor may discharge upon a shuttle conveyor, in which case the pile may be formed in both directions; or, it may discharge upon a second conveyor over the pile, which is then formed by a movable tripper.

Fig. 1 shows an arrangement using the shuttle conveyor at a plant of the Chicago Gravel Co. While this installation handles washed gravel, it could be equally well adapted to stone handling.

Figs. 2 and 3 illustrate a storage system at the Canada Crushed Stone Corp. of the type employing a tripper. Either system outlined above presupposes an elevated structure for the distributing conveyors. For most plants a 24-in. conveyor running at about 250 to 300 ft. per minute will have ample capacity for stocking out, this being in the neighborhood of 200 tons per hour. A narrower conveyor is undesirable on account of side spill.

Reclaiming from such a storage pile may be by several means. At the Canada plant, directly underneath the storage pile, is a tunnel and belt conveyor, delivering to an elevator, discharging into bins for loading either cars or trucks. At the Chicago Gravel Co.'s plant tracks are provided paralleling the pile and a 20-ton locomotive crane with 1½-yd. bucket used for reclaiming and loading directly into cars.

Belt conveyors cost, erected and in place, including belts, motor and driving gear complete, but not including structures:

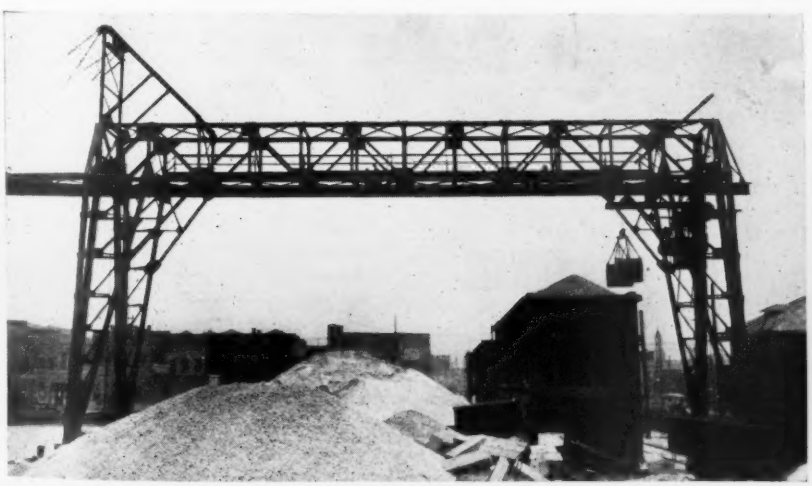


Fig. 8—Gantry bucket crane

Fig. 9—Storage system using a car and trestle

For lengths 50 to 100 ft., per sq. ft.....$12.00
For lengths 100 to 250 ft., per sq. ft..... 10.00
For lengths over 250 ft., per sq. ft..... 8.00

Shuttle conveyors will cost approximately 50 per cent more per square foot. Covered belt-conveyor galleries of average height, say, 50 ft., including steel towers, with plank walkways each side of the belt, and corrugated steel siding and roofing, erected, but not including foundations, may be approximated at $30 per running foot. Reinforced concrete tunnels, 8x8 ft. inside, with walls averaging 12 in. thick, complete in place, with necessary excavation to place top flush with ground level and tunnel gates for feeding every 15 ft., may be approximated at $35 per running foot. Self-propelling trippers complete with two-way discharge spouts, will cost erected for: 24-in. belt, about $625; for 30-in. belt, about $700.

Based upon these costs, a storage system of the belt-conveyor type, in which the conveyors are 24 in. wide, the conveyor from the plant being 150 ft. long, the conveyor over the pile being 300 ft. long, a tunnel under the pile 400 ft. long and the towers about 50 ft. high, thus giving a capacity to the pile of about 50,000 tons, we have an investment we may conservatively place at $50,000. In 10 hr. 2000 tons can be easily handled either in or out of storage with this system, and it takes about four men to operate it—one man in the galleries, one in the tunnel, and two at the carloading end of the reclaiming conveyor.

With labor at 50 cents per hour and electric power at 3 cents per kilowatt-hour, the direct cost of putting stone in storage and reclaiming will be about 2½ cents per ton, which allows about ½ cent per ton for the maintenance of the system. Taking depreciation at 5 per cent annually, interest on investment at 6 and taxes and insurance at 2, the total fixed charges are $6500 per year. The tonnage put through the storage system, of course, determines the spread of these overhead charges. If 100,000 tons are handled annually—which is probably a maximum for most locations—the fixed charges become 6½ cents per ton and the total cost 9 cents.

Locomotive cranes are much used in storage systems, both for stocking out and reclaiming. The Chicago Gravel Co. uses such a crane exclusively for reclaiming. At the Canada plant tracks parallel to the storage pile on one side and a crane is used to operate a bottomless drag-scraper for pulling the sides of the pile, which are ordinarily "dead" storage, to the center for reclaiming through the tunnel gates.

Fig. 5 shows the storage system of the Solvay Process Co.'s plant at Jamesville, N. Y., wherein a locomotive crane is used exclusively both for stocking and reclaiming. A 20-ton crane with 1½-yd. bucket and 50-ft. boom on railroad trucks costs in the neighborhood of $12,000, and ordinarily costs about $40 per day to operate, including all charges. Such a crane will load under average conditions of operation and with a moderate amount of switching to be done, 10 to 12 cars per day of 10 hr. from the pile, and, assuming 50-ton cars, the cost would be 6½ to 8 cents per ton. Stocking out and unloading from cars under the same conditions, six to eight cars may be handled at a cost of 10 to 13 cents. Records of operation at much greater speeds than just cited have been obtained, but the foregoing probably represent the average ordinarily obtained. It may, therefore, be said that, ordinarily, locomotive-crane storage and reclaiming costs run from 16½ to 21 cents per ton.

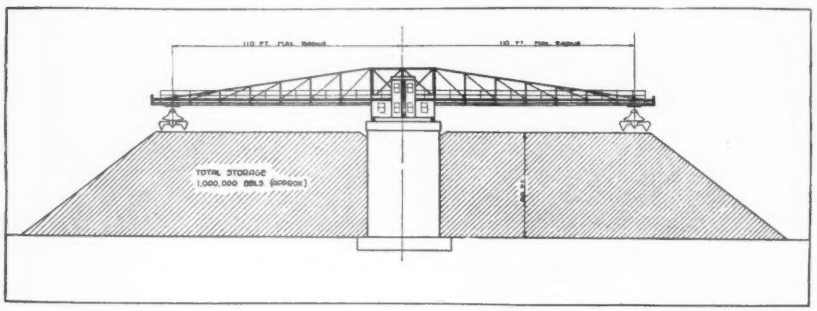


Fig. 10—Diagram of clinker storage crane at Riverside Portland Cement Co.'s plant

The crushing plant of the Blue Diamond Materials Co. near Corona, Calif., has an interesting storage system, utilizing an aerial cableway. This system was put in, in 1916 by the Lidgerwood Co. and consists of an 800-ft. span radial cableway, equipped with a 2½-yd. clamshell bucket. The head tower is stationary and the tail tower is arranged for travel on a 450-ft. segmental track. Material from the screens is diverted to belt conveyors alongside the storage bins, delivering to a transfer platform 60 ft. long. Here the aerial bucket picks it up and delivers to the stockpiles.

Reclaiming is by the same bucket, which then delivers to another portion of the transfer platform, from which by gravity chutes and conveyors it is delivered to cars. The wooden towers are 125 ft. high. The main carrying rope is 2¼ in. in diameter and the travel, hoisting, and closing lines of the bucket are separately operated from a three-drum 300-hp. hoist, motor-driven. This is a complete and highly efficient arrangement of an aerial cableway system of storage. The bucket may be dumped from any height and in any position along the cableway without setting stops or trips of any kind. One man can operate the cableway, for which is claimed a capacity of about 90 tons hourly in either direction. The tall tower operates through an arc of about 30 deg. and, with a pile 40 ft. in depth, the storage capacity is about 200,000 tons. The capacity could be greatly increased by extending the arc through which the tail tower may run.

The cost of such a plant today, exclusive of tracks for the moving tower and exclusive of the transfer platform, but including hoist, cables, bucket, and wooden towers, would be approximately $45,000. Fig. 7 shows a general view of this installation.

The use of gantry bucket cranes, similar to those used at coal and ore docks for the storage of stone, is not general, except where such material is to be loaded into or unloaded from boats. Except where considerable tonnage is to be handled per day—that is, upward of 1500 tons in 10 hr.—the investment required is not warranted.

Some idea of the cost of such apparatus may be gained from the following: A 240-ft. span bridge, with 328-ft. overall trolley travel, having an hourly capacity of 300 tons, would cost erected, but including no tracks, about $100,000. The pile under this bridge, 40 ft. deep, would contain, roughly, 400 tons to the running foot. An 80-ft. span bridge with 25-ft. cantilevers at each end for loading or unloading cars or barges, equipped with a 1½-yd. bucket, will handle 150 tons per hour. The pile will have a capacity of about 50 tons per foot of length and such a bridge would cost, exclusive of tracks, but erected, around $50,000.

A similar bridge with 100-ft. span and 13-ft. cantilever at one side only would give a pile containing 60 tons per foot and would cost approximately $60,000. A 180-ft. span bridge with 2-yd. bucket will handle 200 tons per hour, give a pile containing 150 tons per foot and would cost about $75,000 erected. The cost of tracks and their foundations in each case would depend so much on local conditions that no estimate can be given. Whenever such a device as we have outlined is used, it, of course, performs both the operations of stocking out and reclaiming and loading.

The means of delivering stone from the plant to a point from which it can be handled by the bridge for stocking out would depend entirely upon the plant arrangement, but ordinarily belt conveyors would be used, delivering either to a pit or a pile alongside the storage site.

Storage by means of small cars run out upon trestles and there dumped, the pile

forming around the bents and underneath the tracks, is a common but uneconomical method of storage (Fig. 9). The cars are propelled along the trestle by man-power, moving cable, or small locomotive. Reclaiming from such a storage may be either by a belt conveyor and tunnel under the pile or by locomotive crane or small steam shovel loading cars on tracks paralleling the pile.

Storage under such a trestle is ordinarily not desirable, as the capacity of the pile is limited, due to the expense of building high trestles. For the same, or less, investment, a belt conveyor system could be installed which would require less attention and be much less expensive in operation.

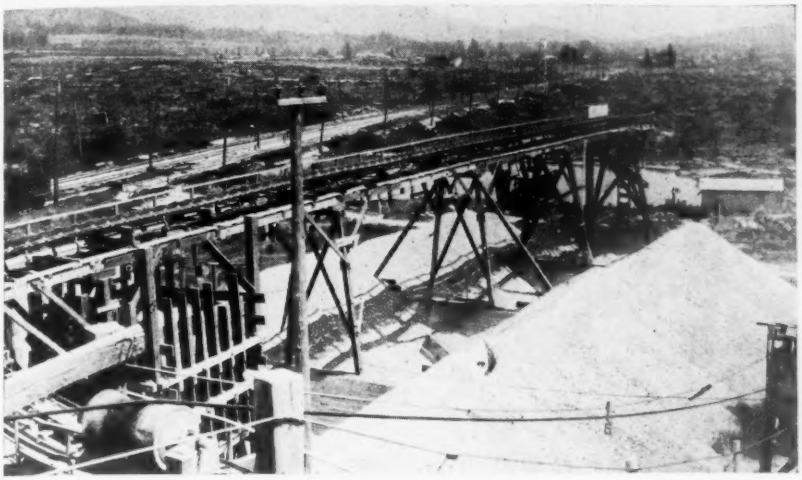


Fig. 11—Pivoted bucket carrier storage system employed by Pacific Rock and Gravel Co., Los Angeles

There are several variations of the major types of storage system mentioned, employing different combinations of methods previously described and using supplementary methods of many kinds. For instance, at the plant of the Buffalo Cement Co. a single line cableway is used for stocking out which is so arranged that the same bins are used by the aerial bucket as for loading cars. For reclaiming, a locomotive crane is used, the loading tracks paralleling the stockpile. For handling screenings and small sizes, stored away from the tracks, a small tractor crane is used, dumping into a movable hopper over a belt conveyor which discharges into cars or trucks, as desired.

Unusual Storage Methods

The Riverside Portland Cement Co. uses for clinker storage a balanced two-arm revolving cantilever crane, each arm having a radius of 110 ft. This revolving crane is mounted upon a stationary concrete pier and serves a pile 50 ft. deep, which, if filled around the complete circle, would have a capacity of about 150,000 tons. Reclaiming in this case is by means of a tunnel extending partially through the storage (see Fig. 10). The Pacific Rock and Gravel Co., of Los Angeles, Calif., is using a pivoted bucket carrier for stocking out and reclaiming in its storage system (Fig. 11).

Summary

It will be obvious from this data that for most crushing plants a belt-conveyor or locomotive-crane storage system will be most economical. A careful investigation by competent engineers will, of course, determine which system is the more desirable or whether a combination of the two may not be advisable.

The amount of storage and the rate of handling to storage and reclaiming, coupled with the annual tonnage to be handled, are the main determining factors. The belt-conveyor systems have the advantage of simplicity, permitting operation by ordinary labor, and their capacity, both as to amount of storage and rate of handling, may be said to be unlimited.

The advantages of the locomotive crane lie in its relatively low first cost and in the fact that it is a complete unit in itself, requiring no additional equipment for handling and spotting cars. In addition, it is an all-'round useful machine, and, when not engaged in work on the storage system, may be advantageously used elsewhere about the plant for hoisting and handling work of all kinds. Against these advantages is the fact that it requires a skilled operator and is rather unlimited in its capacity both for stocking out and reclaiming.

The aerial cableway has particular advantages where the storage ground available is uneven and therefore not well suited for a reclaiming tunnel, or tracks for crane operation. Its capacities in tonnage handled in a given period are, of course, rather limited, as has been shown. The initial cost of a cableway storage system of any extent is considerable, and unless a radial system is used with moving tail tower it does not lend itself to easy expansion of capacity.

The traveling bridge crane of the ore-bridge type is one of the most efficient machines for storage systems, but until it is desired to handle material steadily at the rate of 1500 tons and upward per day of 10 hr. and deal with large tonnages, the investment required is not ordinarily warranted. Bridges of the size mentioned previously are about the smallest that may be profitably employed and their capacities are considerably in excess of the average crushing-plant requirements.

Discussion of Stone Storage

CHAIRMAN SLOAN: Are there any questions you wish to ask Mr. Smith?

F. O. EARNSHAW (The Carbon Limestone Co., Hillsville, Pa.): I would like to ask the gentleman if he has ever had any experience in preparing the ground for this stone before it is dumped.

MR. SMITH: No, not much, but you can't ship the dirt very well and there is danger of picking that up through your reclamation system.

THOS. SULLIVAN: I would like to ask a question. If the stone is stored by the use of a belt conveyor and reclaimed by the use of a belt conveyor, in the storage process the stone separates a great deal; that is, the coarse separates from the fine. How is the stuff averaged up again when you want to reclaim it? Nobody wants to get all the coarse stuff and nobody wants all the fine. The coarse stuff goes to the sides and it seems to me it would stay there until all the fine stuff in the center is gone.

MR. SMITH: If it is properly sized, that will not be very great. That can be prevented by carrying spouts down so that the stones will not get a long fall in the open.

W. L. SPORBORG (Rock-Cut Stone Co., Syracuse): I saw a storage system once where they reclaimed the stone and the storage floor at the time I saw it was asphalt.

W. S. SNYDER (Templeton Limestone Co., Templeton, Pa.): Would it be practical to store stone with a drag line scraper?

MR. SMITH: There is an objection to storing with a drag line scraper where you are storing more than one size in the same pile.

MR. SNYDER: Is it practical to store your stone in different sizes or more prac-

tical to store it all in one pile and rescreen it when you go to ship it?

MR. SMITH: That is a pretty hard question to answer. When you store crushed stone or gravel with a locomotive crane, you do not store it in a core pile, and when you pick it up with a crane you pick it up substantially as you put it in; whereas, with a conveyor from a trestle, the coarse particles will always fall to the outside and the fines are left in the center. They are the ones to come out and your coarse material is left until the last.

maintenance are concerned, will run anywhere from 1 to 1½ cents per ton. The actual labor cost will run anywhere from 2 to 4½ per ton. We have never known it to exceed a cost of 5½ cents per ton to place it in stock. We can store anywhere from 17,000 to 18,000 tons of one size stone, and we have found it a very economic way of storing it, and then it is reclaimed by a locomotive crane.

I will show you the crushing outfit first.

Fig. 1: Now, gentlemen, we are right in the city of Buffalo and we will demonstrate it by the houses 300 or 400 ft. away. We use the Sanderson "Cyclone" well drills and while we have some trouble, we pride ourselves as having mighty good neighbors, the same with the Buffalo Crushed Stone Co.; they pride themselves with good neighbors and they are good neighbors of ours.

The photographs we are showing here were taken just recently and somehow or other the bucket on this cableway dropped and crushed into the loading platform. We use that for an emergency purpose of loading the small sizes when necessity requires it. Fig. 1: This is the cableway from the loading end and shows a stockpile there now of at least 12,000 tons.

Fig. 2: This is the crushing plant. It shows the cableway going up overhead and dropping down.

Fig. 3: This shows the loading apparatus. The man stands over at the left. It is controlled by a wheel which opens and closes the chute and the stone drops into that bucket, which is about 2-yd. capacity; and it is then hoisted.

Fig. 4: Up to the carriage is a lift of about 15 ft. When the bucket is loaded, the man at this loading end signals to the man in the tower and he immediately applies the power and when he starts pulling

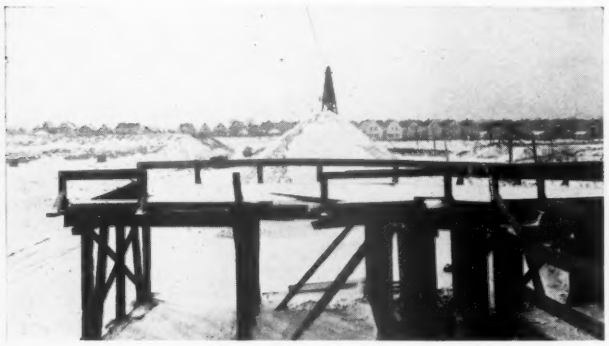


Fig. 1—Storage cableway from the loading end

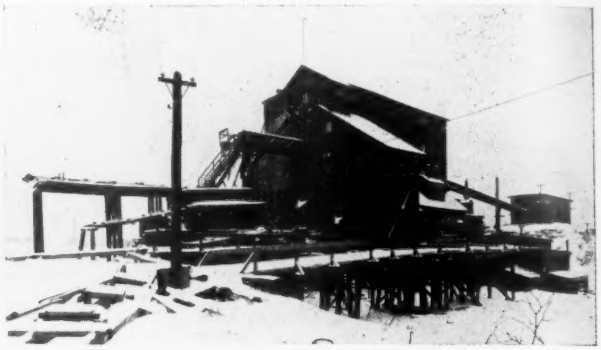


Fig. 2—Crushing plant of the Buffalo Cement Co.

CHAIRMAN SLOAN: Any other questions?

Next is discussion of storage and shipping, led by C. A. Freiberg, general manager, Buffalo Cement Co., Buffalo, N. Y. He has some interesting slides.

Storage System of Buffalo Cement Co.

MR. FREIBERG: You have just heard from Mr. Smith the necessity and needs of a storage pile. Also he has shown you some very interesting equipment in the way of storing material. We have a system that has been in use now over 25 years. Some time ago Mr. Rockwood came through the plant, as he usually does as you know, and he was very much impressed with it and has often spoken of it, and he asked if we wouldn't have some slides made and bring them here and give you a brief outline as to its method.

This is an aerial cableway; it has a span of 360 ft., the tower is 80 ft. high, the center is 65 ft. high and gradually tapers down to 40 ft. at the loading plant. We can store anywhere from 40 to 50 tons per hour at a very small cost. It is operated by two men, one man in the tower and one man at the loading end. Originally it was installed by the Caldwell people of Chicago, and operated by steam, but in the last 10 or 12 years it has been changed to electricity. It is operated with a 25-hp. d.c. motor. We generate our own current. This outfit has cost us practically nothing so far as we know other than just painting the cableways and keeping the bucket in shape. The actual cost, as near as we can ascertain it, as far as the equipment and

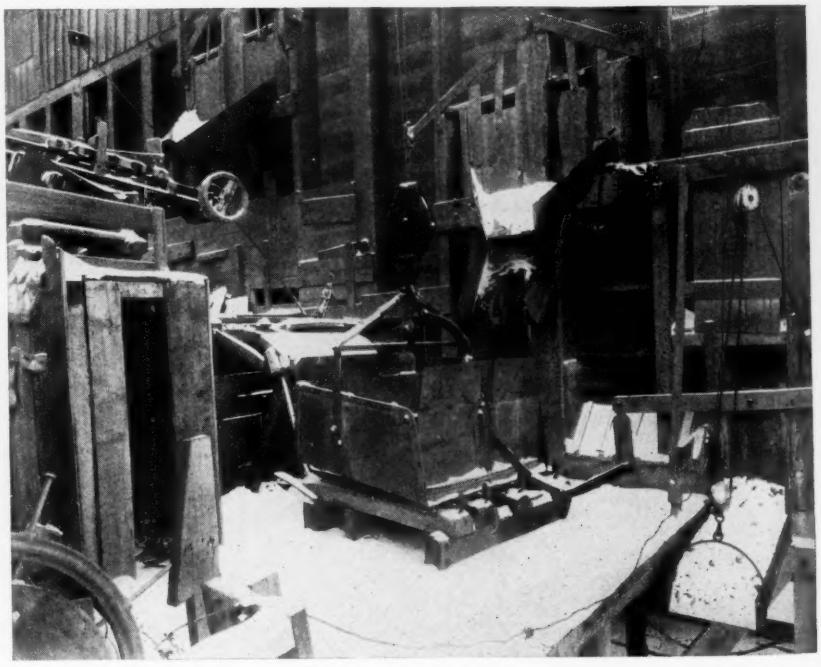


Fig. 3—Loading apparatus of storage cableway

this bucket up, the man at this loading end controls it with a brake so there can't be any sudden movement or irregularity.

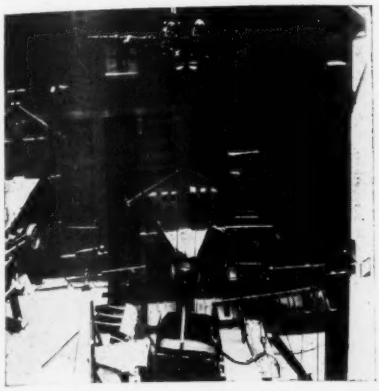


Fig. 4—Another view of the loading apparatus

This bucket catches into the carriageway above and proceeds out. The pulling cable is ¾ in. and the carrying cable ½ in. in diameter.

Fig. 5: It passes out to this tripper, which works automatically and dumps the bucket.

Fig. 6: This shows you after it is dumped, and the bucket is now proceeding back. The going back of this bucket is controlled by a counterbalance at the end and requiring no power to bring it back; it is controlled by the operator in the tower.

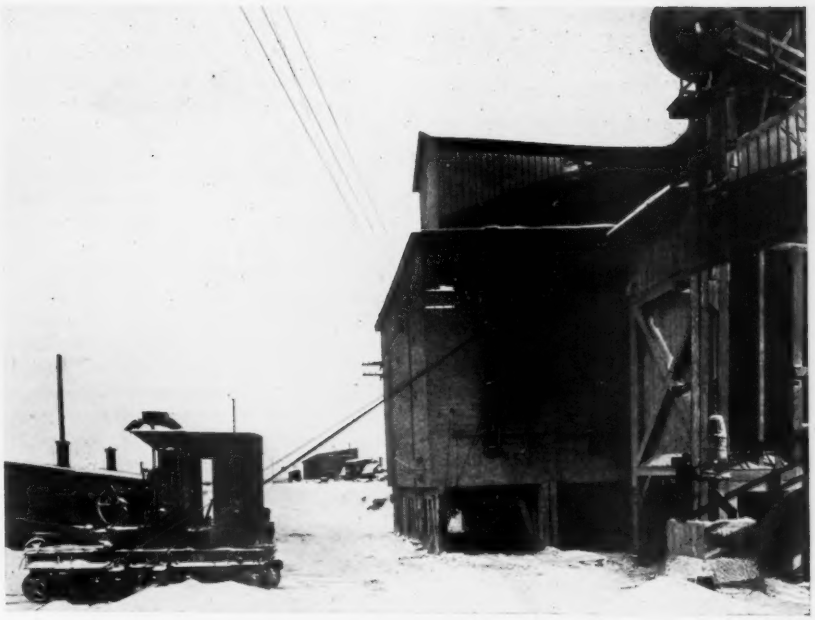


Fig. 7—Counterweight for returning the bucket

Fig. 7: You see the counterweight at this end here proceeding up on that shaft, and the other cableway shows how it is sunk down in here. This is our loading plant showing loading both for teams and cars and our locomotive train which reclaims it.

Fig. 8: This shows the tower 80 ft. in height. The operator sits up on top and has complete vision of all the workings of the outfit.

We find it a very convenient outfit and would not dispense with it.

MR. SPORBORG: What is your locomotive crane loading cost per ton?

MR. FREIBERG: It will vary, depending entirely, of course, on the amount of loading to be done. We can load anywhere from 10 to 12 tons an hour and the actual labor cost will run around 3 or 4 cents and the actual cost, including upkeep and everything else, will run from 8 to 10 cents per ton in an hour.

Fig. 5—Bucket on the way to the tripper

Fig. 6—Bucket returning after dumping

Fig. 8—Tower 80 ft. high at far end of cableway

General Discussion of Stone Storage, Mining and Other Features of Quarry Operation

A. L. MOSCRIP (Consumers Co., Chicago, Ill.): I didn't get an answer to my question. I want to explain it a little further. My point on this was this: Supposing that you didn't have storage at all, that you had six cars today and you would run your plant and give six cars and you had 12 tomorrow. Now, if your overhead is, say, $30 a day at your plant and you could run on $230 and your sales are just breaking even, is it making money to run? In other words, is it profitable to put storage in stock when you are actually putting an investment in it? I mean this: Ordinarily if you are storing extra, practically all that storage is costing is your stripping, drilling and blasting, plus your expense of putting it in stock. Now if you are operating on two or three cars a day and storing, in all likelihood you are putting an investment in the storage.

CHAIRMAN SLOAN: There isn't any doubt but that you are building up an investment when you are putting goods in storage. It seems to me the common sense way would be, if you have determined your future needs in market are going to require that storage and if your trade in the interim will warrant you loading from storage, to cease operation until after business begins.

MR. MOSCRIP: From an economical operation, isn't there an exact point where you should stop running a plant; that is, assuming you have enough in storage to carry on through the winter season?

CHAIRMAN SLOAN: All right, who will answer that? Where is the exact point where it is advisable to shut down where you have enough in storage to carry you through a dead season? That is the meat of the gentleman's question.

MR. SPORBORG: I can't answer it, but I would like to hear the answer. We operate without storage. As Mr. Moscrip says, we have operated at times when the value of the stone we shipped was just about enough to pay the outgo; we have operated for an hour and a half a day or two hours a day, operated with 12 men in a quarry, and it is pretty tough going, and I would like to have somebody tell how far it pays to go in this matter of storage, how much money it is advisable to put into it, what considerations, and how they come out.

I listened to the paper by Mr. Smith here and one of the things I did hear was that it costs a lot of money to go into the storage business. I would like to know how much money you would make in investing $10,000 or $50,000 or $100,000 in storage. Of course, I don't ask anybody to expose their figures, but I would like to know something about it from those who are in it.

CHAIRMAN SLOAN: The gentleman asks a very pertinent question. It must be of interest to a lot of you. The only thing that occurs to the chair is that you might consider the spirit of co-operation with some of your neighbors and instead of you all doing business at a loss, let one of you operate at a profit.

Who has the next suggestion? Is there anything further on the storage question?

MR. SMITH: A great many gentlemen have asked what is the proper limit in investment in a storage system. I tried to give you some idea of what those things would cost in the paper I read. I want to call your attention to the fact that such questions that have been asked are not at all easy to answer offhand. It is a very dangerous kind of information to give any one in an offhand manner. It is dangerous to make a guess, and such information would be worse than valueless. How much money can properly be invested would require a considerable amount of time and effort to figure out. I appreciate the spirit in which the question is asked and I am sorry it isn't possible for one person to carry such things in his head. It has been my experience since I have been in the engineering business that that sort of information is very difficult.

New Haven Trap Rock Co. Experience with Storage

PRESIDENT EAMES: I would like to answer Mr. Sporborg. We have a storage. Last spring we had about 60,000 tons in there. We find storage in our case most profitable. We have different weather conditions in the East, and we stored constantly until a week ago yesterday, and we had to shut down our plant. Last year our peak of storage was 60,000 tons. That was used up, there was practically nothing in our storage by August 15, I think, or surely by October there wasn't anything that we could get out of that storage.

We find by this method we can dump in our storage when we are short of cars. It has cost us on an average the last two or three years about 4½ cents to reclaim —a little more than that before the war; but it certainly is a great advantage to a plant of our size, as we have a very large production and we have to keep it constantly moving.

MR. MOSCRIP: Were you shipping anything when you were storing?

PRESIDENT EAMES: Oh, yes, running just the same and loading cars.

MR. MOSCRIP: Do you get a higher price when that comes out of storage?

PRESIDENT EAMES: No, we do not.

MR. MOSCRIP: You would run, then, and store?

PRESIDENT EAMES: Oh, yes. It keeps the cost of your plant down. We drive our plant just as hard in the lean months as we do in the biggest months. Our biggest month last year was 87,000 tons, which was August or September.

Our plant is about seven miles from tide-water. We operate a branch steam railroad. This railroad goes down through Stony Creek and we have a terminal there about 450 ft. long, and we have in that about 70,000 tons. We have loaded up as many as five boats a day. We have loaded a boat in an hour and 15 minutes, and we have to keep a large amount of stone there all the while for these boats. In fact, we have had as high as 17 and 18 boats in our terminal at one time. It keeps us moving all the while to keep that storage moving down to load a boat if a boat is waiting there. We find it to great advantage.

Storage Means Better Service

JAMES SAVAGE (Buffalo Crushed Stone Co., Buffalo): I think the whole question of storage resolves itself into the increasing ability of the producer to render service. We are not all Rotarians, but Rotarians have a motto which I think we can all afford to follow, "He who serves best profits most;" and that thing will work out to the benefit of the people who take care of their customers by providing storage to take care of peak loads in the summertime or to afford occasional delivery of stone during the off season.

MR. SPORBORG: Mr. Eames, all of the stone that is crushed in your plant goes into storage and then out again, is that correct?

PRESIDENT EAMES: No, not all of it. I should judge about 25 per cent really goes in storage.

CHAIRMAN SLOAN: Any other questions?

MR. SNYDER: I would like to ask the gentlemen if they have any trouble with their stone coring on them and what methods they take to prevent it—that is, the fine accumulating in the center.

PRESIDENT EAMES: As far as we are concerned, we don't have any trouble of that kind.

Mining Stone

CHAIRMAN SLOAN: This discussion is not limited to storing alone.

MR. SNYDER: Mr. Chairman, I have felt somewhat like I was in the wrong church here. We mine our stuff, and it seems that all the talk has been on the open quarry. I would like to hear some discussion on the mining end of it. I think we will be compelled to do more mining in the future owing to the transportation being so high. I mean by that, underground mining of stone.

CHAIRMAN SLOAN: I am told the

American Lime and Stone Co. at Bellefonte, Pa., operate an underground quarry. I know of no other.

MR. SNYDER: We have been operating one for about 14 years at Templeton, Pa., and there are several of them around there in that section.

J. C. KING (Carbon Limestone Co., New Castle, Pa.): Underground quarries where the stripping is sometimes 300 to 400 ft. overburden are very prominent in the state of Pennsylvania. The United States Steel Corporation operates about 14 of the underground quarries. The cost of mining stone is about equal to the cost of quarrying stone where the burden exceeds 20 ft.

CHAIRMAN SLOAN: That is quite interesting. I am sure the members would be pleased to hear a discussion about it. What can you tell us about your operation, Mr. Snyder?

MR. SNYDER: Mr. Chairman, I am afraid that the time would be too limited to go into the details. We have an 8-ft. vein of limestone that we mine; I believe it is the thinnest vein that is being mined in the United States today. Our cost naturally would run higher than in open quarries, but our methods are somewhat different than what is used in open quarries. We use a small drill, we have a device of our own that we made for drilling purposes and we have sort of a square board we made to aid our drillers in measuring up our angles. We put our angles in something like this, and anywhere from 10 to 12 ft. in an angle. I guess the rest is just something similar to the outside quarry, except the expense; it is much more expensive.

MR. SCHROEDER: There is a mine operated at Moline, Ill., an underground quarry, and the man who owns the quarry told me he would not attempt to compete with the cost of operating the open quarry.

MR. SULLIVAN (Omaha, Neb.): There are two quarries out in our neighborhood that are mining stone. They just run into the side of the hill and quarry their stone that way. The quarries out in Nebraska claim that the cost of producing stone by the tunnel method is much less than taking it out by the open quarry method. The ledges of stone out there where they operate are about 24 ft. thick. At the top of the 24-ft. ledge is shale which runs from 4 in. to a maximum of 2 ft. thick, and that makes a very nice dividing line between the stone that is quarried and the roof. The roof is an 8-ft. ledge of good solid stone, and above that comes some shale and some more ledges of stone. At some of these mines the quantity of the stone and shale above made it impossible to take out the ledge below; that is, made it impossible to take it out at a profit, so they just couldn't disturb the stuff above at all, but would go under it and take out the 24-ft. ledge by the tunnel method.

CHAIRMAN SLOAN: Do they use a pillar system for supporting the roof?

MR. SULLIVAN: They just simply make a tunnel in there; the widest are 45-ft. wide. They use two cars; that is, they make these tunnels wide enough to handle two cars so that when one car goes out, there is another one there for the men to load. There is no provision whatever made for supporting the natural roof. The natural stone makes the roof and is sufficiently strong to support the overburden.

J. G. OWENS (Water Street Trap Rock Co., Water Street, Pa.): I am not from the American Lime and Stone Co., but they are friendly competitors of ours in the business. They are operating a mine quarry very successfully; it is very high grade limestone, they tell me. They say it costs a little more to operate than the open quarry. They have open quarries at Bellefonte as well as the mining operation. I think that was the operation written up in ROCK PRODUCTS in July. On account of it being a very high grade of limestone, they go to that extra expense.

Now there are other operations right in our own city where they operate by mining, and one fellow tells me that he doesn't find any difference in the cost except where the overburden runs over about 18 to 20 ft., then he would prefer the mine. In these quarries where they do mining in our section, it is solid rock and they don't have many with roof troubles; they leave sufficient of the solid rock there to support it and leave a pillar standing here and there.

They seem to think where the stone is of good quality, mining is altogether profitable.

A New Type of Shovel for Quarrying

By George E. Deatherage

General Manager, the Hoar Shovel Co., Duluth, Minn.

THE heading under which this short paper is being presented is rather deceiving, for it leads you to believe that a radical change from established practice has been made.

However, that is not the impression that it is meant to give. In fact, we have stuck absolutely to the best established practice—that of steam-shovel operation, with which you are all familiar.

SPECIFICATIONS—SHOVEL No. 2

Swinging Engine	4½ hp.
Hoisting Engine	7 hp.
Crowding Engine	7 hp.
Dipper	6 to 10 cu. ft.
Operating Space	7 ft. x 7 ft.
Capacity Breast	14 to 16 ft.
Overall Length	6 ft. 7 in.
Width	3 ft. 6 in.
Height	6 ft.
Width, seat off	42 in.
Height, dipper off	4 ft. 4 in.
Clean-up Radius	7 ft. 8 in.
Weight	5400 lbs.
Hoisting Gear	9/16 in. chn.
Track Gage	18 in. to 4 ft. 8 in.
Wheelbase	37 in.

NOTE: This is the shovel generally applicable to the rock products industry. Smaller shovels are built but these are used in the metallic mines in small drifts.

What we have done is to reduce the wide margin between the laborer and his hand shovel, and the smallest of the regular steam shovels or excavating machines. You will admit that there is a wide gulf between the two.

There are large hammers and small hammers, large cars and small cars, large pumps and small pumps, and even large men and small men. Why should there be only large steam shovels?

The shovel that we have brought on the market was designed to work *in between* the laborer and the smallest of the standard steam shovels. It weighs but three tons, and in the smallest size requires but 5 ft. 6 in. headroom and a space the same distance in width in which to operate. In any place where a man can stand erect and stretch out both arms, we can furnish a steam shovel to operate in that space. The Hoar shovel duplicates every movement of the time tested and proven modern steam shovel and will handle any material that they will handle. It is in fact the "baby steam shovel."

Operation is by compressed air or steam, there being no self contained power unit, the shovel being in practice, connected to the pipe lines that carry power to the quarry face for drilling purposes. In general use the equipment is fitted to operate on the existing narrow-gage track and to dump into the standard narrow-gage dump car.

The question of track arrangement is more important in "baby shovel" operation than in the operation of the larger sizes.

To get the maximum output a double track must be used at the shovel and cars must be kept there ready for loading. "A machine may have utility but it is producing revenue only while it is at work."

In the December 16 issue of ROCK PRODUCTS, Dr. Bowles gave figures which indicated that the usual output per man in quarry work, hand loading, as being 16 tons. I can agree with him there as personal observations in a number of operations has been stated by me a number of times to be but 15 tons. He also gave figures which indicated that the output per man in a quarry that was steam-shovel loading as being 112 tons per man.

The "baby shovel" will split this difference and give an output of from 40 to 50 tons per man. This is not figuring direct from the stripping operation, but in actual tons loaded at the quarry face after the stripping is complete. Normally, then, you can figure that this small shovel will replace eight to ten hand shovelers, allowing one pit man and one shovel operator, and give you a production of from 150 to 200 tons a day.

Best Used Underground

Underground, the shovel will make still greater savings, for there is no competition with larger types of machines, and the laborer has had things pretty much his own way until the last few years. The war stimulated progress in underground mechanical loading and the metallic mines especially were quick to take advantage of the savings to be made and to free themselves from annoying labor problems. There is today more of an opportunity for the non-metallic miner to cut his loading costs than in any other single industry that I know of at this moment. There is no doubt that underground costs in loading can be cut to half what they are at present.

In quarry work we feel that the advent of the small shovel has made it possible for every small operator to have the benefits of mechanical loading. No longer can it be said that loading in small quarries may be done at lower cost by hand labor, and that the steam shovel is only advantageous for a large output.

Details of Construction

Taking up the details of construction on this machine in the few moments that I have left, I would refer you to the accompanying illustration on page 93.

The wheels are standard chilled car wheels. It is sometimes desirable to change the pitch or height of the machine, and in that case wheels of different diameters are furnished or the truck bearings and axles altered to suit conditions.

The truck base is a substantial steel casting to which is attached the bottom swinging ball race, also a steel casting. Track clamps are heavy forgings to stand a maximum of abuse.

The base, for power units and frame, is a heavy steel casting with the upper swinging ball race fastened to it. Balls are of a special hardened steel especially designed for this purpose, and the heaviest kind of service.

The hoisting engine is of the rotary and reversible type. This engine operates a hoisting drum through a train of machine cut steel gears. A quickly detachable steel chain transfers the power to the end of the dipper stick.

The crowding engine is of the same type and drives a cable through a worm and worm gear which self locks the drum and prevents the carriage from backing up when crowding into the pile.

The swinging engine is a vertically mounted rotary and swings the shovel through 360 deg. by means of intermediate gearing to the swinging or bull gear attached to the bottom ball race.

No clutches are involved in the operation of these engines, as they are directly reversible by means of throttles direct-connected to the operating levers. The fact that the engines are directly reversible at full speed gives the desired "kick" so necessary in steam-shovel operation.

The end frames are heavy steel castings accurately machined to fit the machine base. The hoisting, crowding and swinging units, together with all operating mechanism, are fully enclosed by the sheet steel covers, thus fully protecting all this from dust and dirt.

The three operating levers are directly connected to the reversing throttles on the engines. The inner lever operates the swinging engine in either direction and the two outside levers are the hoisting and crowding levers. The control of the engines is positive at all times, there being no clutches or brakes to cause trouble and require adjustment.

The carriage casting is a special steel casting, accurately machined and hand-fitted to the steel track girders. Grease cups are provided to bearings that are not taken care of by the force feed oil pump.

The floating dipper stick is to provide a means for following the bottom, as the leverage applied allows the dipper point to automatically adjust itself to obstacles encountered on the bottom.

The dipper sticks are heavy steel channels securely cross braced. These and the arms are adjustable to suit conditions.

The dipper is a miniature steam shovel dipper with standard latch and manganese steel teeth. For rock the dipper has a capacity of 6 cu. ft.

Shovels Now in Operation

It may interest you gentlemen to know that these shovels are mucking out the tunnels at the great Hetch Hetchy project for the city and county of San Francisco. This year the world's record was broken for hard rock tunneling on this job, 796 ft. of 12-ft. tunnel in one month. All of this is in an extremely hard granite, and this 796 ft. was driven from one heading.

In the Coeur d'Alene district of Idaho they have reduced the rate for 8-ft. tunnel driving to $11 a foot. This is a reduction of $6.50 over the lowest rate ever paid in the district.

In Michigan and Minnesota the shovels are handling wet, heavy, and sticky ore with a saving of nearly 50 per cent in labor over the old methods. Advices from these operators show a saving of from $900 to $2500 a month from one shovel. One operator paid for his shovel in six weeks from the savings over hand labor.

We have data sheets that may be filled out giving us information as to the details of your quarry. On mailing these to our office we can arrange to send one of our engineers to your work and make recommendations for installation. There is absolutely no obligation in doing this. It is simply a method of co-operation between the manufacturer and the operator, and in co-operation lies the secret of progress and cost reduction.

Steel-Belt Conveyors

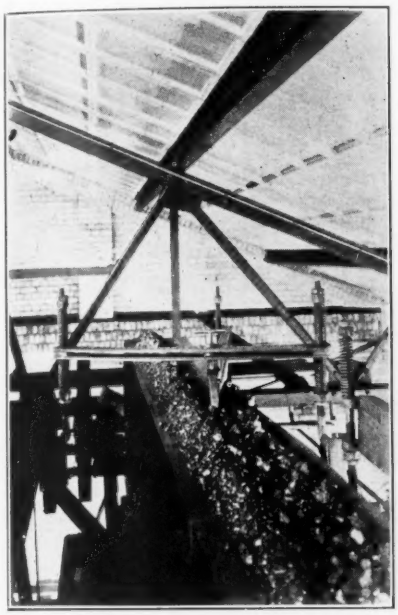
By Harry Carlson, M.E.
Sales Manager, Sandvik Steel Co., Inc., New York City

I THINK I can safely say that a year ago very little was known in this country about steel belts and the extent to which they have been used in conveying many different kinds of materials, although more than 1300 installations had previously been made in the many different phases of the industry in Europe and other foreign countries. Today the situation is a little different and I think I can now say that a large percentage of engineers know that a flexible steel band conveyor exists and are familiar in a general way with such steel belts, their general features of design and the many uses to which they can be put with decided advantage from both an efficiency and economy point of view. Since the first of January of this year, when steel conveyor belts were first introduced into this country, installations have been made for handling castings, sugar, cossettes, phosphate rock, sand, coal, clay, limestone and clinker.

It has been gratifying to note the interest displayed by American engineers in this im-

portant development, and the receptive attitude they have taken toward its adoption.

The chief reasons why members of the National Crushed Stone Association should be interested in steel belts is because of their simple arrangement from the point of view of design, low initial cost, reduced upkeep expenses, low power consumption, efficient service and long life. It is obvious from only a casual survey of the question of steel belts that a high-grade tempered steel will



Showing the scraper removing part of the load

stand up much longer when conveying highly abrasive materials than will the textile, rubber and balata belts now employed. This has been conclusively demonstrated by more than 300 installations in this field alone, and their high efficiency is speedily being recognized.

It is unnecessary for me to mention at the outset that much experimentation and conscientious application have been necessary to bring the steel belt to its present state of development. I shall confine myself in the following remarks to information of a general character regarding the steel belts and their general features of design as they will be applied in the crushed-stone field.

Manufacture of the Steel Belt

The steel belt known on the market as the Sandvik belt, manufactured by the Sandvik Steel Works of Sandviken, Sweden, internationally known as quality steel manufacturers, is made from the very best Swedish charcoal steel, cold rolled, hardened and tempered; hence, it possesses a hard, smooth and dense surface, giving it great durability and high wear-resisting qualities. It can be satisfactorily applied for handling hot as well as wet materials, and run in the open air subjected to the influences of rain, snow and sunshine, and under extreme changes of temperature. The steel belt does not deteriorate when idle. Its smooth surface facilitates unexcelled cleanliness to be obtained by the simplest means.

At present it is rolled in widths up to 18 in., one-piece lengths up to 350 ft., and thicknesses down to .032 in. The edges are rounded and smooth. The flexibility of the material may be judged from the fact that the coil of 300 ft. of 18-in. belt is sent out packed in a case 2 ft. square, weighing approximately 2 lb. per running foot.

Standard practice in steel conveyor belt design calls for a 40-in. diameter head and tail pulley, the face of which is usually made three-fourths the width of belt and crowned in the usual way, but made flat one-third of width in center.

Although the Sandvik conveyor can be designed in two ways, either sliding on wood runners or made rolling on idlers, with or without skirting boards, the rolling type without skirting boards is always used when heavy loads of abrasive materials are handled. The idler units, depending on the load, can be spaced 6 to 13 ft. apart on the top strand, and 30 ft. apart on the return strand.

As compared with flat-rubber belts of the same width, the steel belt possesses greater transverse rigidity and therefore a higher capacity, as the edges, even with a one-sided load, do not yield in a downward direction and the belt does not run out of alignment. This allows a relatively broader part of the belt to be used for carrying the load. These attributes are obvious and are due to the fact that the steel belt is less flexible than the textile fabric.

Steel-Belt Installations

The speed at which the steel belt should be run depends on the length of conveyor—ordinarily it varies between 135 and 300 ft. per minute—and capacity is thereby determined. The average speed, however, for the average length conveyor is about 200 ft. per minute. Considerable attention is given to the proper designing of feeding hoppers to insure the maximum load per foot of belt.

The joint is an ordinary riveted lap joint with short overlap and can be made complete in less than an hour. Countersunk rivets are used. For punching the holes a special tool is supplied which makes the jointing work extremely simple. It has been found after extensive experiments with many different kinds of joints that the one herein mentioned is by far the simplest, most efficient and economical.

In many cases existing structure can be easily adapted to accommodate steel belts, and under favorable conditions existing end pulleys and idlers can, with a little modification, be kept in use also. Erection is comparatively simple and full instructions are supplied. Most customers undertake the erection themselves, merely having an experienced erector sent along by the manufacturers to generally inspect after completion, mount the belt, make the first joint, and start up.

A special feature, which should commend itself most favorably to your attention, because of its low initial cost of construction and efficiency in operation—doing away with the present cumbersome and expensive trippers—is the remarkably simple method of discharging materials by means of plow or scraper, either made stationary or traveling. A steel belt can be closely scraped. It does not stretch and the tension devices are therefore very simple, as they have to take up only trifling variations in length caused by changes of temperature when handling hot materials.

The drive can be arranged either at the head or tail end to suit the local conditions of purchaser and is equally efficient at either end. When required, both strands can be used simultaneously for conveying in opposite directions, and under suitable conditions the conveyor can be made reversible.

Inclines vary somewhat with the material being handled. In a general way a figure

Shows the conveyor handling coal up an incline of 14 deg.

of 1 in 4 is the limit for a smooth belt which has to be scraped off for unloading, but if terminal unloading only is to be used, slats can be affixed to the belt at intervals and the inclines increased to about 1 in 2.75.

The steel-belt conveyor is not a "cure-all," but is claimed to be simpler and more durable than the already simple band conveyor, to offer stronger material and avoid the large number of working parts of other

types of conveyors, and to be competitive in price.

Discussion of Steel Belt Conveyors

QUESTION: What effect has the weather on that belt?

MR. CARLSON: No effect whatsoever. The steel doesn't rust. There is a surface rust formation that takes place, but it doesn't penetrate; it serves as a preventive for further corrosion.

QUESTION: How long a conveyor belt of that type can you operate?

MR. CARLSON: The longest belt we have in operation now is 850 or 900 ft.

QUESTION: And they will drive from either end?

MR. CARLSON: From either end, yes.

QUESTION: Does it run flat?

MR. CARLSON: It runs flat and steadily. There is no vibration, so you can load it practically out to the edge.

QUESTION: How is delivery made to prevent spill?

MR. CARLSON: When the load leaves the feeding hopper, on account of the fact that there is no vibration in the steel belt, the load on the belt will stay until it is dislodged by a scraper or discharged over the end pulley. There is no vibration. We design our hopper in such a way that the load is formed when it leaves the mouth of the hopper and stays there until it is deposited.

QUESTION: Then you furnish a feeding hopper with the conveyor?

MR. CARLSON: Yes; we have a model running downstairs.

Showing two conveyors feeding the hoppers

Electric Storage Battery Locomotives

By C. W. Chappelle

Sales Engineer, Industrial Division, Ironton Engine Co., Ironton, Ohio

WHAT is known as the non-metallic mining industry presents today one of the broadest and most interesting fields for the development of industrial haulage apparatus. In this particular field the hauls are usually comparatively short and the machines engaged in the transporting of materials are in actual use for a large portion of the working day.

For the production of stone, whether it is taken from an open quarry or whether it is mined like coal, the transportation of the raw material is one of the biggest factors, both as regards the available output per day and the production cost per ton.

There are at the present time four commonly used methods of haulage or about four different types of haulage machines used in this industry; namely, steam locomotives, gasoline locomotives, electric trolley locomotives, and last, but by no means least, the humble mule. Cableway system, compressed air locomotives and electric storage battery locomotives have been used to some slight extent.

Perhaps the most extensively used machine at present is the steam locomotive. Both the saddle-back type with the rigid wheel base and the geared or shay type have been used and have proven very satisfactory, with the exception of the high cost of operation.

The gasoline locomotive probably ranks next in popularity to steam, but the necessity for complicated gearing, particularly in the larger sizes, together with the somewhat unreliable character of the internal combustion engine with its continual demand for repairs, puts it at a disadvantage.

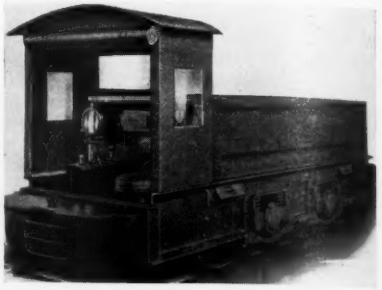


Fig. 1 shows the Type L locomotive with cab for outside use. This machine is especially designed for quarry work and can be equipped with very large battery capacity. It is built in sizes of from 4 to 12 tons

The electric locomotive has been gradually gaining in favor and with the increasing tendency to electrify quarries and mines of all kinds it will gradually supersede all other types of haulage machines.

Broadly speaking, electric locomotives may be divided into three classes or divisions; namely, trolley locomotives, third-rail locomotives and storage-battery locomotives, or a combination locomotive, having any two or three of these features.

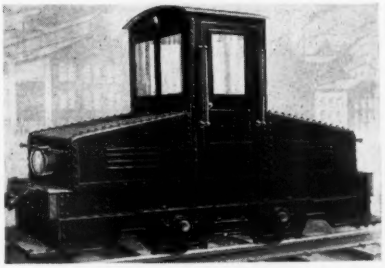


Fig. 2 shows the Type K locomotive and is designed for heavy haulage work and car shifting. It is built in sizes of from 8 to 15 tons and can be furnished in either a straight storage-battery or combination type, with a battery capacity of from 50 to 100-kw.-hr.

All of these electric locomotives have several points in common, such as ease and simplicity of control, low center of gravity, which means less trackage up-

Fig. 3 shows the duplex or combination type locomotive of from 6 to 7 tons capacity with battery capacity of from 35 to 40-kw.-hr.

keep, and lower cost of operation and repairs.

Owing to the fact that it is rather difficult to maintain an overhead system of conductors in the average stone quarry, due to the necessity of continually shifting the tracks, and which is further complicated by the use of steam shovels, the trolley locomotive is placed at a disadvantage and this applies to some extent, although not so much, to the third-rail system.

The storage-battery locomotive, on the other hand, carries its power house on its back and is free to travel anywhere that you can lay a track, its radius of operation being limited only by the size and capacity of the battery with which it is equipped.

Perhaps the reason why storage-battery locomotives are not so well known and are not at present used extensively in the stone-producing industry is because they were first developed for coal-mining work and the manufacturers devoted most of their time and energy to perfecting them for that particular field.

The results which have been obtained with storage-battery locomotives in coal mines service during the last five or six years have been so uniformly successful where properly applied that today the storage-battery locomotive probably is receiving as much, if not more, prospective attention and consideration than any other piece of machinery connected with coal mine operation, and I believe it is safe to predict that it is only a question of time when the producers of non-metallic minerals will come to know the many advantages of this particular type of locomotive for this work.

While the first cost of a storage-battery locomotive is somewhat higher than the corresponding cost of either a steam or a gasoline locomotive of the same rated weight, yet the maximum draw bar pull of the battery locomotive is so much greater than that of the other two, that based on actual pulling capacity the difference in first cost is not so great.

For outside work these locomotives are equipped with cabs for the protection of the motorman, and the batteries are so arranged as to be easily accessible for inspection, cleaning and repairs.

The Edison battery is of the alkaline type and consists of plates using nickel and iron in their construction, these plates being immersed in a solution of caustic potash in a steel jar or container. This makes a very rugged and long-lived battery.

The lead battery is of the sulphuric acid type and consists of plates built up of lead oxides pasted on a skeleton grid composed of lead and antimony. These plates are immersed in a dilute solution of sulphuric acid and use a hard rubber jar as a container. This type of battery is likewise very rugged.

During the past two or three years there have been so many important improvements in the construction of storage batteries that the manufacturers have been able to put out a new form of guarantee so that it is possible to approximate very closely the actual cost of operation per year or per month of a storage-battery locomotive, which is a difficult thing to do with either a steam dinkie or a gasoline locomotive.

Based on our experience with storage-battery locomotives, and we are the largest exclusive manufacturers of these machines in the world, I believe it would be safe to figure upon an operating life of from four to six years for the Edison battery and from two to three years for the lead type of battery in industrial haulage work.

One of the first difficulties experienced with the earlier types of storage-battery locomotives was the lack of simple, rugged and fool-proof charging apparatus. Today this point has been overcome and charging apparatus has been perfected which will properly charge the batteries and automatically protect them from overcharge or other damage. You may be interested to know that the life of a storage battery depends more on its being properly charged than it does upon the actual hard work you may give it in hauling material.

In a short paper like this it is not possible to go very deeply into the question of haulage costs, but I am going to give you a brief outline covering approximate average costs of a storage-battery locomotive of from five to six tons weight and having a draw bar pull of about 3300 lb.

Assuming the cost of one locomotive and charging equipment to be $5000—

Interest on investment at 6 per cent per year	$300.00
Depreciation on chassis and charging equipment	123.00
Depreciation on storage battery per year on three-year life	537.00
Charging current, 250 days per year, purchased power 3 cents per kw.-hr.	450.00
Labor—1 hr. per day at .45 per hr.	113.00
Total cost per year	$1583.00
Cost per day based on 250 working days per year	6.37

This does not take into consideration the motorman's wages, as this item would probably be the same for any type of locomotive used. The hostler or station service, where a number of storage-battery locomotives are used, is very much less than where steam machines are used.

The haulage problem in every quarry has to be considered by itself, just as the haulage problem in every mine does, as no two are alike. As stated before, the radius of a storage-battery locomotive is limited by the size of its battery. In moderate-size quarries a straight storage-battery machine will handle the work very nicely and in larger operations where there are perhaps long runs between the working face and the crushing plant, a combination locomotive could be used to advantage, a protected third rail could be used for supplying current for the long runs and the storage-battery end would be used while working around the shovels and making up trains and doing necessary switching.

It is interesting to note that the engineers of practically all of the large steel plants in the country are studying this method of haulage at the present time. As the storage-battery locomotive becomes better known and understood its application to industrial work in this country will greatly increase because it is a money-saver in haulage. In Europe, and particularly in Germany, where economy of operation and production is studied more than it is here, this type of locomotive has been widely used for a number of years.

Discussion of Electric Storage-Battery Locomotives

QUESTION: How long will it run on a 10-hour shift?

MR. CHAPPELLE: We would have to do just the same as has been done in the coal industry. In figuring locomotives for coal mines or any industrial haulage, the conditions are studied and a battery is properly selected to do that work. If you have a certain amount of work to do covering 10 hours, a battery would be figured large enough to do that work. It is hardly possible to buy a storage battery locomotive off the shelf.

A Gearless Gyratory Crusher

By W. J. Cavanagh

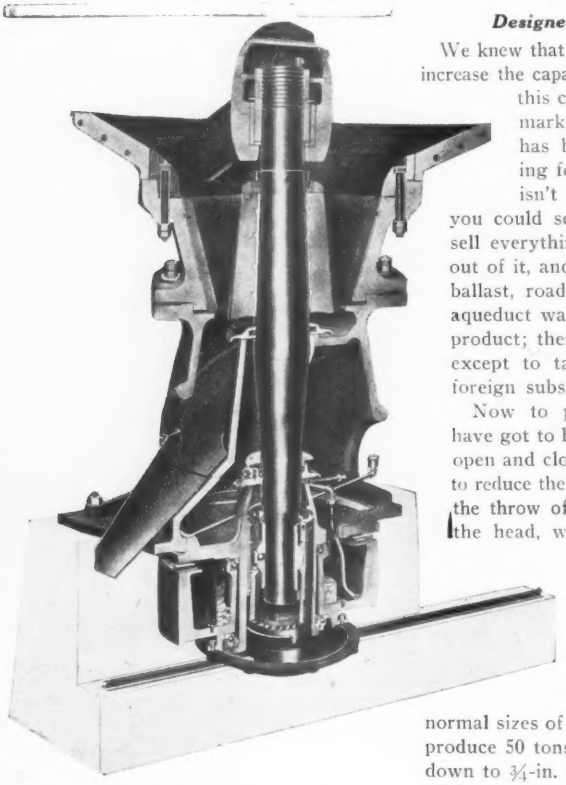
Engineer, Kennedy-Van Saun Mfg. & Engineering Co., New York City

I HEARD Mr. Buchanan talking about the advisability of using a jaw crusher and Mr. Roberts' paper about the advisability of using a gyratory crusher, and I am not going to take sides with either one, or go against either one; but I am going to say that the principal objection against the gyratory crusher by the jaw crusher lovers is the fact that it had gears, bevel gears, grinding, grasping gears that take power and wear out. And it takes two great bearings to carry them, drive them, and that is the one big feature that the jaw crusher people have against the gyratory crusher.

You notice there are no gears in this crusher at all. It was made some years ago. It isn't actually new, in fact, there are quite a few gentlemen in the audience who have

used this crusher. I was talking a few minutes ago to Mr. Boxley (W. W. Boxley, Roanoke, Va.) and he told me the one he put in last year was giving every satisfaction, doing more than the manufacturers had represented it would do.

In place of the gears, we put a pulley; and at first we started to drive it with a rope, which is a very good drive, a very positive drive; it is a good transmission, but around a stone quarry there is a lot of dust and grit and we found the rope is a bad thing, so we changed to a belt. Any kind of a motor or line shaft will drive it. The return belt is guided by a small idler which is furnished with the machine.



A gearless gyratory crusher

Variable Speed Drive

Now the advantage of this kind of a drive is that you can increase the speed of the machine. The one thing that limits the production in any crusher is the discharge area and the number of revolutions per minute which open and close that discharge. On the standard gyratory crusher, about a No. 6 we will say, the shaft gyrations are from about 87½ to a little over 100 revolutions per minute. The different companies drive the countershafts at different speeds. It runs from 300 to 425, but anyhow the shaft runs from 87½ to 100. This crusher will run 250 without any trouble and it will run with less horse-power than the geared crusher. It will run about 25 per cent less actual horse-power and per ton it will run about 50 per cent less horse-power, because this crusher by its speed has a greater production.

Now you notice that the concaves are absolutely vertical; there is no flare-off of the concaves like the standard crushers because this crusher was made only for a finishing crusher—for a reduction crusher. The head is a little shorter, but a good deal wider from point to point. They run in three sizes—No. 25, No. 37 and No. 49—and those numbers indicate the dimensions across the large end of the head.

Designed for Recrushing

We knew that the speedier crusher would increase the capacity, but what we designed this crusher for was because the market for the last few years has been more and more calling for small sizes in stone. It isn't so many years ago when you could sell crusher run, you could sell everything after you took the dirt out of it, and it was good for concrete, ballast, roads, in fact, the New York aqueduct was built with that kind of a product; there was no separation at all except to take out the dust and the foreign substances.

Now to produce small stone, you have got to have a machine that doesn't open and close too much; you have got to reduce the throw. We did; we reduced the throw of the eccentric and elevated the head, which put it up at a point where it had less flow, and we found that with this crusher, with the No. 37, which is the intermediate size and which has a capacity when crushing to the normal sizes of 100 tons an hour, we could produce 50 tons an hour of stone crushed down to ¾-in. and under.

Now we found another thing which we had not been prepared for, that it didn't make as much dust as the slow running crusher. It strikes a quick, snappy blow, and it shatters the stone. We found also that we reduced the slippage in the crusher about 50 per cent.

The Pittsburgh Plate Glass Co., at Ford City, Pa., have two of these No. 37 crushers, and they crushed 380,000 tons of silica rock, which is probably the most abrasive rock crushed today, before they changed the concave. In the ordinary crusher you will wear out the bottom of the concave and then throw it away. In this crusher, on account of it being vertical, the concaves are interchangeable, you can turn them around and wear out the other end, so you get twice the wear out of the concave.

Belt Drive for Largest Crushers

As I say, we only made this for recrushing, but we found that it was such a tremendous success that it operated at such a little cost that the maintenance cost was reduced so much, there was no reason on earth why we shouldn't make all our gyratory crushers without gears, and we have done that. We make them as large as No. 66. That means 66 in. between the concave and the head at the top. We are making shipment to Japan now of two No. 66 crushers. That is the biggest crusher in the world. It weighs something like 900,000 lb. Heretofore the biggest one we made was a No. 60. Our No. 42 weighs 450,000 lb.

Now you notice that the pulley of this crusher is put down on the bottom here, down under, and it becomes a part of the bottom plate. This is the standard gyratory crusher made by the Kennedy people for a number of years with the ball and socket eccentric. Then we made three bearings here instead of two; there was no side pull and we found that we distributed the friction of two bearings between three, so we reduced the friction there at least 50 per cent, and we found that we could drive these crushers even with less power proportionately than we did the first gearless crusher we made.

I saw a No. 6 crusher of this type over at Owens, Ohio, where they previously had a smaller crusher, and they were driving it with a 25-hp. motor and an 8-in. belt, and when they changed it to a No. 6 crusher so as to increase their capacity, they didn't have their 40-hp. motor at hand, so they put it up with the 25-hp. and 8-in. belt and it was running for some weeks when I got there and running without difficulty.

The Storage Problem

Now I heard some talk here this afternoon about storage, which is quite a problem, I know. I have been in the stone business myself, in the operating end of it and everything. I have helped to build crushers and I have built plants and operated plants, operated some of the big plants in Canada and this country, too, and I find that one reason for storage is the fact that you have got a marketable stone, but you have also got some stone that is not marketable at the same time.

As a matter of fact, there are times in the year when you have a demand for a whole lot of fines, what the Pennsylvania Highway Department calls chips, that is, around ¾-in. and under. Now if you could make all chips you wouldn't need to have any storage, because your larger size you could crush down into chips with the gearless crusher. The gearless crusher that is made will produce all your material so you will have a market for it. I saw an instance of that over at York, Pa., some time ago. There are about a dozen quarries there within a radius of ten miles. An order could be got there for I think it was 100 cars of ¾-in. stone—¾-in. and under—and nobody dared take the order because they had no market for any size over ¾-in., and they couldn't produce ¾-in. stone in a 100 per cent quantity.

The A. M. Hake Co. sent for me to see if I couldn't fix their crushers so they could produce that size of stone and grab that

order. I told them it was impossible, but if they would buy one of the smaller types of the gearless crusher they could add it to their plant and produce everything under ¾-in.; they did it and got that order and they were running all winter while everybody else was shut down. Now I think that is quite an interesting thing, because it costs money to store stone. If he had taken that order and attempted to produce it and produce other sizes with it, he would have had to store them out in the field and in the springtime when the market came for them, he would have to collect it again. That costs money, and everybody knows it costs a lot of money to pick up stone.

Concave Replacement

Now you will notice in this crusher the concaves are so put in, and so they are in the gearless, that you can take them out and reset them without taking out the spider. If any of you gentlemen have gyratory crushers, you know what a job it is to take one of those spiders off, especially if it is any size, and put it back again. It takes you pretty nearly a day to have two men go around there and tighten up those bolts after you do get it back. In this crusher you can take those concaves out and reset them in a couple of hours. I have done it myself often without removing the spider at all. It has a self-locking arrangement on the head here which actually locks the head on tighter than when it is originally put on. If there were any tendency to get loose at all, the natural action of the shaft would throw that head around and tighten it so it would never come off until it wears out. It is made with either a solid chilled iron head or cast iron head and manganese concaves.

The Robins Cataract Grizzly

By Thomas Robins, Jr.

THE Robins Conveying Belt Co. have recently offered to the stone-crushing industry a type of screen so novel in its features of construction and operation that it would seem not out of place to tell something of the history and development of this machine.

The Robins company have, for many years, enjoyed the belt-conveying business of, and have done much of the engineering work for, a very large limestone producer. This company had always experienced difficulty with primary screens for taking out the larger sizes of stone from 1½ in. up. The tremendous tonnages handled at this plant demanded screens of exceptional capacity and mechanical limitations forced them to consider the development of some form of screen with a greater capacity for overloads than possessed by the revolving screens commonly used in your industry.

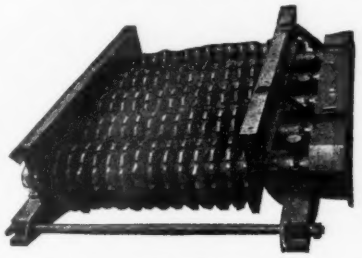


Fig. 1

It happened that the Robins company had developed for the screening of coal and coke a rotary grizzly of a type which possessed great capacity in relation to the power required to drive it and the space which it occupied. In fact, these machines had been installed in virtually all large coke-handling plants and in certain large coal tipples, such as, for instance, the Steel Corporation's plant at Lynch, Ky., with a capacity of 40,000 tons per day, where Robins grizzlies were used for the sizing of bituminous coal.

This grizzly was of the type shown in Fig. 1, consisting in a number of chilled iron discs, mounted on parallel shafts. It was obvious to all concerned that these machines would not stand the abuse incident to handling stone, but at the time it was felt that an application of the same principle could be made for this purpose.

After considerable experimentation, a model machine was constructed and tests were run with small quantities of material. The results of these tests showed that the machine possessed the desired qualities of capacity, low power consumption, and ability to withstand the punishment common to stone handling. Our friends then gave us orders for two of these machines to be shipped to their plant, with the understanding that the grizzlies were first to be tested under actual operating conditions at our works at Passaic, N. J.

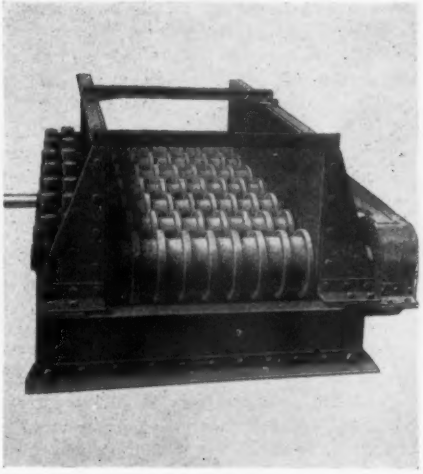


Fig. 2

We therefor constructed a life size screening plant and installed the two grizzlies, one 6-in. mesh and one 1½-in. mesh. A quantity of trap rock was purchased from a nearby quarry in New Jersey and the tests went off without a hitch. The two machines, with the slight changes necessarily made evident by the operating conditions, are still running and giving satisfaction in the plant for the customer, who had sufficient confidence to encourage us to build the machines. These people have recently ordered two more machines. As you will see from Fig. 2, these grizzlies differ only in the shape of the discs and in the fact that they are more heavily constructed, from those originally used in coal and coke plants.

Description of Grizzly

Since the initial installation was made, a number of other machines have been sold and are giving splendid satisfaction. The machines can best be described as follows: Each machine consists of a series of shafts set on a structural steel base, on which shafts are mounted heavy chilled iron or manganese discs of such shape that the screening surface, composed of these discs, contains a large number of openings of the size of the desired separation. These shafts are power driven. The drive is transmitted from motor or line shaft by the belt, chain or gears to the center shaft of the grizzly. Each of the other grizzly shafts receives its power from this center shaft, through chain and sprocket transmission.

The screen is installed at an angle of about 20 degrees, as indicated by Fig. 3. The shafts revolve in the direction of flow of material and are driven at differential speeds; i. e., the shaft at the top of the screen is turning the slowest and the shaft at the bottom of the screen is turning the fastest, the speed of each shaft being faster than the shaft just behind it.

This fact, together with the angle at which the grizzly is set, prevents the material from lodging in the grizzly openings. The upward force applied to any individual lump being greater than the downward force imparted to it by the shaft behind, the lump is moved forward. The screen presents an effective screening area *across its entire surface*, and for this reason, if for no other, the machine can handle very large tonnages of material at a high rate of screening efficiency. The machine can be used for either or both of two purposes. First, *scalping the material*

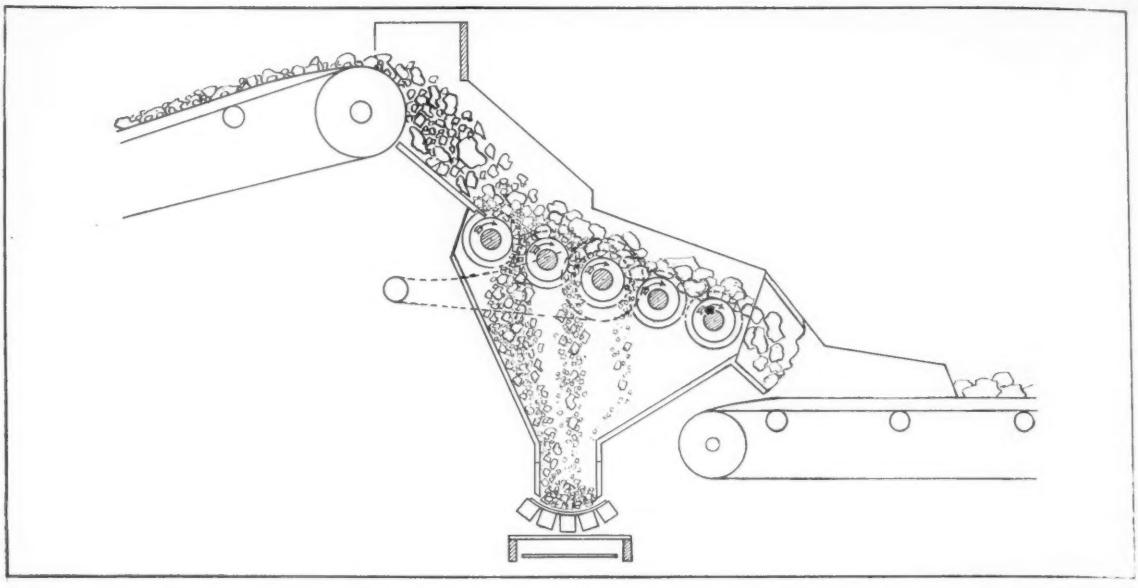


Fig. 3

going to a crusher, or second, *accurately sizing finished material.*

Scalping

The bar grizzly is considered generally satisfactory for scalping purposes when the tonnage handled is low and the material is not of such shape as to clog in the openings. When the tonnage, however, is in excess of 100 tons per hour and particularly where the load varies greatly, the cataract grizzly is particularly well adapted to the work to be done. It is self-cleaning in every sense of the word; can be started up with a load on; and the experience of operators has been that no supervision is required. We have noticed that in the case of bar grizzlies, a man is generally standing near to keep the openings clear of material.

Sizing

When a screen is required for the final sizing of material, the points generally foremost in the operator's mind are cleanliness of product, low first cost, low power consumption and low maintenance. The manner in which the material tumbles over a cataract grizzly gives it every opportunity to pass through the screen if it is undersize and has a decided tendency to jar loose any dirt adhering to the larger size lumps. We have a letter in our files from one of the users, stating that over a considerable period of time very careful tests indicated that there were less than 4 per cent of undersize passing over this screen; and it is impossible for oversize material to pass through.

We recommend these machines for making any desired separation between 1 in. and 6 in. Where the separation desired exceeds 3½ in. in size, we recommend that the machine be of the gear-driven type. It is likewise advisable to use the gear-drive type when hard trap rock is being screened. In the case of dolomite and the other less hard grades of stone, such as calcite, gypsum, etc., we have found the chain drives to be satisfactory. In this connection, we might add that one of these machines which has handled over 1,000,000 tons of limestone is still in service with the original discs and no appreciable wear has yet occurred.

Space and Power Required

The machine is extremely simple to install since it comes mounted as a complete unit on its base. It is necessary to support it on two heavy timbers, merely securing it in place with bolts at the four corners and connecting it up with the power source.

The screens occupy small space for the amount of work they do. A machine to handle 300 tons per hour is only 7 ft. long by 5 ft. wide. Machines having a capacity of 750 tons per hour are less than 10 ft. long by 6 ft. wide. The reason for this extraordinary capacity in such small space is that with this type of screen, its entire surface is at all times effective screening area. Compare this with a revolving screen where the material never covers more than a sixth to an eighth of the screening surface at one time.

Power requirements of this machine are extremely low, running from 10 hp. maximum for a machine capable of handling up to 150 tons per hour to 30 hp. for a machine capable of handling 750 tons per hour. It is interesting to note that in one plant this machine did the work previously done by a revolving screen requiring *seven and two-tenths times the actual horsepower shown by readings.*

Summary

To sum up the merits of this machine, it has been almost universally acknowledged by everyone who has seen these grizzlies in operation that they appear to be a logical answer to the problem of cheaply sizing large stone. Their appearance in action suggests at once a maximum of result with a minimum amount of effort expended. They can no longer be considered in an experimental stage because they have proven themselves to the complete satisfaction of some of the very largest stone producers in the country, to the extent that we have received orders from these concerns for additional machines. While it is probable that we still have much to learn about this type of screen, it is an assured fact that the machine has been sufficiently developed and satisfactorily proven to warrant the investigation of its merits by anyone requiring a machine to perform the general class of work for which the cataract grizzly is intended.

Now every crushing plant has its own screen problems. We have about nine models to take care of different size separations.

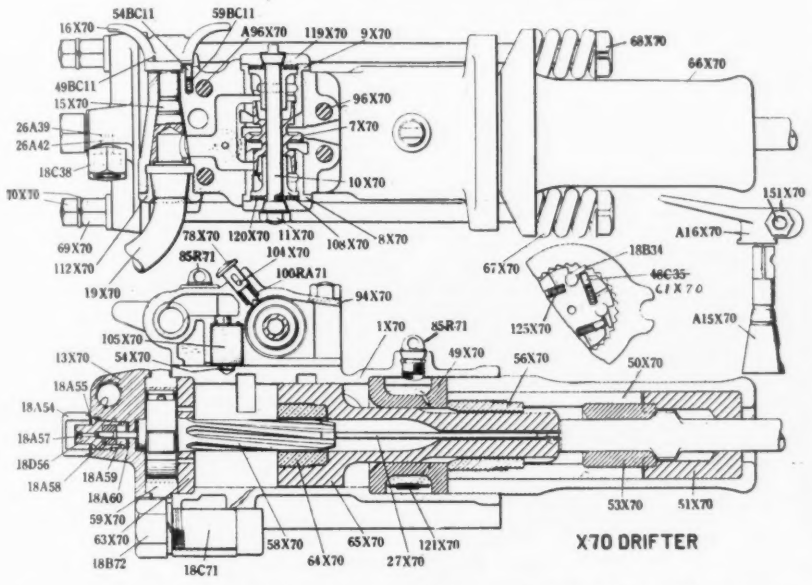
All of you have experienced the superior wearing qualities of manganese steel, but so far we have been unable to establish that the increased wearing value of manganese is in proportion to the increased cost on these machines. Probably that will develop itself as we go along. We still have a lot to learn about it, but so far every one that has been sold has been followed by repeat orders. We really think we have the answer to a problem that has worried stone-crushing concerns a long time.

A New Compressed-Air Drill for Snake-Holing

By Albert L. Worthen
Vice-President, Connecticut Quarries Co., New Haven, Conn.

I RATHER hesitate to bring these facts to the attention of this convention because the adaptation of this drill to quarry work was first made in our quarry, and we have only had the machine in operation for about three months.

First, it may be well to tell you a little about ourselves. We are operating six quarries in the state of Connecticut, all in trap rock. Our deposits are of extremely irregular surface contour with overburden of from nothing to 6 or 8 ft. We have always practiced the bench method of drilling and blasting, using a 3⅝-in. piston tripod drill driving 24-ft. holes vertically—horizontally or at different angles—as the strata and condition of the face after previous shooting might require.



Large hand-hammer drill using 1¼-in. hollow round steel and weighing about 215 lb. Equipped to operate either wet or dry

Part List for X70 Drifter

19X70 Air Inlet
112X70 Air Inlet Cap
85R71 Oil Plug
59BC11 Ratchet Pin Spring
54BC11 Throttle Ratchet Pin
78X70 Blower Button
100RA71 Blower Button Spring
104X70 Cotter Pin, 3/16x1 1/2 in.

TEE HANDLE

15X70 Throttle Valve
16X70 Throttle Handle (Tee)
49BC11 Throttle Cotter Pin, 3/16x2 1/8 in.

LEVER HANDLE

A15X70 Throttle Valve
A16X70 Throttle Handle (Lever)
151X70 Bolt, Nut and Washer

CYLINDER AND PARTS

1X70 Cylinder (including Studs)
85R71 Oil Plug
96X70 5/8-in. Stud, Nut and P.L.W. (2)
A96X70 5/8-in. Stud, Nut and P.L.W. (2)
49X70 Cylinder Front Bushing
65X70 Piston
64X70 Riffle Nut
121X70 Chuck Lubricator complete

FRONT HEAD AND PARTS

66X70 Front Head
50X70 Chuck (back part)
51X70 Chuck Jaw (1 1/4-in. shank)
53X70 Chuck Bushing (1 1/4-in. shank)
56X70 Chuck Nut
67X70 Front Head Spring (2)
68X70 Through Bolt (2)
69X70 Through Bolt Nut (2)
70X70 Lock Nut and P.L.W. (2)

ROTATION PARTS

58X70 Rifle Bar
18B34 Pawl (4)
61X70 Pawl Plunger (4)
125X70 Pawl Plunger Spring (4)
59X70 Rotation Ratchet
63X70 Rotation Washer

VALVE CHEST AND PARTS

94X70 Valve Chest complete, including all the parts listed below
94X70 Valve Chest, Bare
7X70 Valve
8X70 R.H. Valve Bushing
9X70 L.H. Valve Bushing
108X70 Valve Seat (2)
119X70 Bushing Covers (2)
120X70 Valve Buffers (2)
10X70 Valve Bolt
11X70 Valve Bolt Nut
105X70 Oiler Cartridge, complete
54X70 Oiler Bolt

BACK HEAD AND PARTS

13X70 Back Head Bare
27X70 Water Tube
18D56 Back Head Plug
18A57 Back Head Plug Bushing
18A58 Water Tube Rubber
18A60 Clamp Seat
18A59 Water Tube Rubbr Clamp
18A54 Back Head Cap
18A55 Back Head Cap Gasket
18C38 Water Hose Spud
26A39 Spud Brass Plate
26A42 Water Spud Rubber

Tripod Drilling Necessary

I wish to state here, without taking any time for explanation, that we have tried well drilling in some plants without success and in other plants were unable to even experiment with that type of drilling because of the impossibility of setting up a well drill. However, we are driving tunnels at the present time at one quarry where experts seemed to believe there was a reasonable chance of success. Should the tunnel method prove successful or the improvement in well-drill methods since our experiments make either or both possible, there will still be necessity for tripod drilling at some and probably all of our quarries.

Last summer a salesman for the Ingersoll-Rand Co. called at my office and during his visit inquired if I was in need of any drills. I asked him why it was that I had to pay $450 for a drill that a few years ago cost $200 and included an allowance for a worn-out machine. His reply was that we in New England were among the few who still continued to use that type and that the small output at the factory of this type held the price where it was.

He remarked that his company had recently developed a hammer drill called the X70 for large tunnel work and asked that I consider the advisability of trying it out in competition with my 3⅝-in. drills now in use. He was willing to guarantee that the X70 would drill twice the footage in an equal time as the 3⅝-in. piston type, but investigation showed that it would necessitate the purchase of a drill sharpener. (We had been doing our sharpening with the exception of our ⅞-in. hammer steel, by hand.)

This meant an initial expenditure including necessary dollies of approximately $2500 which we would be forced to make even should the new drill not prove satisfactory. The price of the new drill was $475; however, only $25 more than the type we were using and which we could return to the Ingersoll-Rand Co. free of charge should we not feel satisfied.

I had about reached the point, however, where I believed hand sharpening of drill steel to be a thing of the past and therefore decided to purchase this equipment and try out the new drill.

New Large Hand-Hammer Drill

This new X70 drill is nothing more than a large hammer drill using 1¼-in. hollow ground steel and weighing about 215 lb. as compared to 410 lb., taking 215 cu. ft. of air per minute as compared with 159 cu. ft. of air per minute for the piston type, and operated on the same tripod. It is equipped to operate either wet or dry and our experience has been that we make more footage drilling dry so long as the hole is dry, but once we strike water, as we do in some cases, mostly in bottom snake holes, it is necessary to attach the water line in order to properly clean the hole.

We started off with a set of drills made up the same as regards starting and finishing bits as we were using on the piston drill, except that the steel was 1¼-in. hollow round in place of 1⅜-in. and 1¼-in. solid hexagonal. We used the same change in gage each 2 ft., namely ⅛ in., and finished with a diameter suitable to take 1½-in. 60 per cent gelatin dynamite, although of course we always spring our holes from three to six times.

The Ingersoll-Rand Co. experts were on the job all the time, but the drill was set up and operated from the start by our own men. We first began by drilling a series of snake holes at the quarry level keeping a close record of the performance of this drill running both wet and dry. We also placed a pressure gage in the air line just back of the supply hose connection so as to determine at what air pressure the drill was most efficient.

The footage with a 3⅝-in. tripod drill varies at our different quarries, as a result of the different formation of the deposit, but at the quarry in question the average was about 18 to 20 ft. per day of nine hours per drill; this average of course included hold-up due to bad seams. At the instant the air was turned into this X70 drill, we all began to sit up and take notice, you could fairly see the steel disappearing into the ledge as the steel used to disappear down the old sword swallower's throat, although the pitch of the feed screw on the new drill was three times that of the old, the driller would not keep the machine cranked up, due no doubt, to his habit formed with the piston drill.

Increased Depth of Holes

To travel over this a little more hastily, the first change that seemed possible was to reduce gage change, cut down our starter bit and eliminate considerable cutting. We therefore reduced this variation to 1/16-in. —just one-half the former—and started again. Results were even better and we thereupon increased our depth of hole from 24 to 30 ft. with absolute success.

Now just a word as to what the drill really did. As I stated before, we averaged 18 ft. to 20 ft. per 9 hr. with the piston type drill and the best record we had at this plant was about 30 ft. I chose Sunday as being a day when the Ingersoll-Rand experts would not be on the job, put my men to work and they drilled that day in 8½ hr., 90 ft., after only three days' experience on the machine. Our average since that time, including drilling on benches and top of ledge as well as bottom snake holes, has been about 60 ft. per 9-hr. day. I wish to state, however, that this difference between the Sunday work of 90 ft. and the average of 60 ft. has been caused almost entirely by the inability through lack of experience with the sharpener to keep the machine supplied with steel. Where, before, we had two men operating the piston drill, we now have one man operating and one man all the time, and two men part of the time, carrying steel to the drill, although it is a fact that we are able in many cases to use the steel a second time.

Now, my object in presenting to you these facts is this: I believe that most quarries still have some use for the tripod drill, and if they are still using them, there is no question in my mind but that this new X70 hammer-type drill will bear investigation by all.

Use of Magnetic Pulleys in Crushing Plants

By J. P. Bethke
Secretary, Magnetic Mfg. Co., Milwaukee, Wis.

I HAVE been asked to prepare a paper on "Magnetic Pulleys," setting forth briefly their relative value as applied to the crushed-rock industry. This is but one of many fields to which magnetic pulleys can be applied economically and advantageously.

I believe you will agree with me when I say that the fundamental reason for engaging in business is to serve mankind. If your service is one of merit, you profit. However, even with the best of intentions on your part your profits are affected in many ways. For example: If you had a fire in your plant, even though it destroyed but just a portion of it, it would affect your profits, not so much from the damage done to the part of the plant, as the effect it would have in production. Each operation is a link in the chain, and where this link is affected in any way it affects profits.

It would be considered very poor judgment on the part of a business man if he neglected to insure his plant against fire. Another effective means of insurance is what is known as U & O—Use and Occupancy. Many business concerns carry this kind of insurance, but I dare say that to consider a magnetic pulley as an additional form of this kind of insurance has never entered their minds. Magnetic pulleys are used as a means of protection to crushing, grinding and pulverizing machinery and guarantee 100 per cent operation.

This form of protection is not alone a means of preventing costly repairs to such equipment, but adds longer life to them, and also prevents a shut-down, which would be necessary in the event of repair. Usually the repairs to equipment of this kind are small as compared to the time lost. Where crushing and grinding machinery is used, it is generally considered the vital or throbbing element of the whole plant. If this equipment is shut down even for a short time, it affects working of the entire plant and a considerable amount of money is lost. One would not think of buying a magnetic pulley as he would a crusher or pulverizer. Why? Because a magnetic pulley in itself is not a necessary unit, but is considered very much the same as insurance. It keeps the plant operating continuously by eliminating iron and steel or what is commonly known as "tramp iron," from getting into the crushing or pulverizing machinery and wrecking it.

Since iron is so universally used, and so necessary to industry, it is obvious it will be found most everywhere and especially around industrial plants. In rock quarries, iron and steel scrap, such as broken drill points, hammers, tools of various kinds, railroad spikes, coupling pins and even chain finds its way into the material which is very difficult to detect on account of the large bulk handled. This is very often the cause of considerable damage where no magnetic pulleys are used. So much trouble is being experienced that producers of crushed rock, cement, coal, etc., are giving more thought to the protection to this kind of equipment from "tramp iron." New installations are being made nearly every day where magnetic pulleys are specified, and in old installations the cast-iron head pulley which has been used is being replaced by magnetic pulleys. Nearly every day finds some new uses for them.

Magnetic pulleys in themselves are an inexpensive piece of equipment to operate. They simply replace the head pulley in a conveying system, and when once installed no further attention is necessary. They do not require any great amount of additional expense for the electric current necessary and little or no attention whatever from the operator, as the operation of these pulleys removing tramp iron from the material is entirely automatic. No piece of tramp iron, regardless of how large or small within the range of capacity of the pulley, ever escapes.

I would like to refer to an installation which, by the way, is one of a great many of a similar kind where the material on the belt is approximately 10 in. deep and 1500 tons of rock are handled by this conveyor in an 8-hour day. This pulley has been in operation considerably more than a year, and during this period not a single piece of iron has passed into the crusher. Previous to the time of this installation, from two to three times a month the plant was shut down for several hours to take up the bearings and make the necessary repairs. Two men were stationed as pickers to look for and remove by hand any tramp iron they might see in the material. With this precaution they still

had a great deal of trouble which has been entirely eliminated.

In this plant the installation consists of a 36-in. diameter by 30-in. face "high-duty" magnetic pulley which delivers material to a battery of four gyratory disc crushers consisting of three 48-in. and one 34-in. size. The management was scarcely able to believe that so great an accumulation of iron could be removed in the average run of 1500 tons of rock per 8-hour day. By the 100 per cent efficiency of the magnetic pulley since its installation early in 1921, the continuous operation of the plant saved the company thousands of dollars, to say nothing of the elimination of the expensive repairs and replacements and the necessary delay which is caused by the making of these repairs.

Big Damage Saved

Magnetic pulleys as a means of protection to this kind of equipment far outweighs the purchase price, installation and operating cost. Damage to large gyratory crushers have been known to cost the management thousands of dollars in a single breakdown. We recall an instance that has come to our attention in which a tooth from a steam-shovel dipper, having worked itself loose and into the conveyed material and without the aid of a magnetic pulley, was discharged into a large gyratory crusher, bending the 16-in. diameter shaft and completely disabling it. To make this repair it required 30 men 72 hours, the plant being shut down during this time.

You may feel a sense of security from the fact that nothing of this kind has ever happened in your plant, just as one might feel a sense of security never having had a fire, still you would not want to be without a magnetic pulley as it is just as sane and sensible to protect your crusher, grinding and pulverizing machinery as it is to protect your plant or equipment against any other hazard.

The feeding of material to the crusher may be done by some other means besides belt conveyors, and not having such a belt conveyor in your plant, you may wonder how a magnetic pulley could be of any use to you. Such conditions have been foreseen and provided for. Short-belt, magnetic-pulley separators have been built so that the material can be shoveled or discharged on them by any simple means, and tramp iron be removed from the material before it is discharged into the crusher. Our engineers have made layouts to meet many special conditions. This service is gladly rendered without any additional cost whatever and is given to prospective users of magnetic pulleys or magnetic-pulley separators.

These pulleys, or pulley separators, operate very much like the ordinary cast-iron pulley except that direct current is supplied to the coil windings which magnetize the steel casting. You may be interested in knowing something about their construction. They consist principally of steel and copper, the steel casting forming the body of the pulley and must, in order to be built right, be of the very best grade of low carbon dynamo steel, properly proportioned with heavy walls and hub cast-spool fashion.

A single rough casting weighs from 150 lb. to 2½ tons, depending on the size of pulley. The casting is machined and assembled on the shaft. It is then very carefully insulated with the best grade of insulating material, and the windings, consisting of insulated copper magnet wire, are wound on in layers very much as thread is wound on a spool, the amount of copper wire used depending on the size of pulley, ranging from 60 lb. on the very small pulleys to 1½ tons and more on the large pulleys. The steel casting, when machined, is provided with grooves in which a coil covering is fitted. After the coil is completed and the necessary electrical connections are made, the electric current is switched on and a preliminary test is made, usually with about 50 per cent more current than is ordinarily used. This is done for the purpose of carefully testing the windings. Later a high-voltage test is put on to determine whether or not the insulation in any way is faulty.

After the windings and the test are completed, the coils are moisture-proofed so that the magnetic pulley will operate under wet conditions without giving any trouble. After these precautions are taken, the coil covers are fitted in place and the pulleys are put into the lathe and crowned. Before shipping, a final test is made so that a pulley in leaving our plant will operate indefinitely. Hand books containing valuable data and information on "high-duty" magnetic pulleys, together with any information that might be interesting on this subject, will be gladly furnished by addressing the Magnetic Mfg. Co., Milwaukee, Wis.

Conquering Cut-Throat Competition*

By G. W. Hafner

Manager, G. W. Hafner, Inc., Auditors and Industrial Engineers, Chicago

IN the face of the universal urge in the human heart for a better world, how futile are those who stand against it! What an ignoble defeat is theirs from their own standpoint—that of practical men making a real fight for a substantial end! All that they cherish falls. All that they scorn triumphs. Yet here is a peculiar thing: The progressive program of 10 years ago is now a part of the structure to which the man who then fought it is now pointing with pride—workmen's compensation, the eight-hour day, prohibition of child labor, woman suffrage, the initiative and referendum, guaranteed bank deposits, rate regulation, and all that. The very edifice that has risen in spite of his clamor—builded in the face of his wrath—he is now consecrating with his devotion. For it is the established order; that is enough.

Now, the trouble is, of course, that men come with these things and try to ram them down our throats. This may be done tastefully; it may be done courteously; the method of forcing it upon us may be saccharine, but we resent it just the same.

When men, with violent arrogance, say to us, "You have got to do this thing in a certain way," we resent that. When they undertake to restrict our liberty of choice, we resent that. They may do it as gracefully and as sweetly as silk and satin, but we resent the thing. The most of us are very largely fighting for the maintenance of our own business, and we feel obliged to treat everybody suspiciously, to repel everybody. The unfortunate necessity which we have inherited from the ages that are gone by is: A man is so obliged to defend himself against bias, pride, avarice, and various other inclinations and tendencies on the part of those about him, that he fortifies himself in a kind of hard way by resisting everything that is presented to him.

There was a Southern-born colonel of a negro regiment of the United States army whose first name was James. He was a small, dapper man, very dignified and very much aware of his own importance.

He had organized three baseball teams in his battalions, and started a series of games for the regimental championship. One afternoon two of the clubs were playing an important game of the series. The commander, watching from the sidelines, thought the rivals were not showing sufficient spirit, and decided to show both outfits that ginger was requisite. He yanked off his service coat, grabbed a bat and declared himself into the game.

"Now, then," he stated, as he advanced to the plate, "for just so long as I've no shoulder straps on, I want you boys to treat me as if I were one of you. I'm not your colonel; I'm a player. Let's go!"

The pitcher sped the ball across the plate and the colonel cracked out a three-bagger. He tried to stretch it into a homer. As he turned third base on the dead run, the coacher for his side opened up:

"Run, you pore lil' sawed-off, knock-

*Copyright by G. W. Hafner.

kneed, bow-legged, pop-eyed, homely white runt! Run! Run! Now slide, old Jimboy, hotdam you—S-L-I-D-E!!!"

The colonel slid and got there. Then he went over and put on his coat.

The Misfortune of Our Inheritance

Yes, we are all constantly trying to keep somebody from taking advantage of us. This, however, is not a virtue; it is part of the misfortune of our inheritance from past ages. Look, for a moment. We all see that the human race, however it comes into the world, comes through the gate of weakness, of want, of imperfection. Every child that is born is at first but an empty sack. Whatever fills it thereafter has to be gained. Paupers we come, crying, absolutely helpless, without power to do anything, lying in the arms of wisdom and love. And we are to learn everything, and by unfolding experience to come to some capacity of self-government and of self-care. The whole world creeps first, and pules, and cries, and wails—comprehends nothing, knows nothing. We are all at zero when we are born. We can cry; we can suck; we can sleep, and that is the sum total of our functions.

Now, what is it in childhood that makes the model or conception of manhood? It is not that the child loves, though the love of a child is precious. It is not that the child is weak, though we delight to protect its weakness. It is not that the child is ignorant. It is that in childhood universally there is the impetus and aptitude to *learn*. It is not a sense of ignorance so much as an appetite for knowledge; and the whole force of the nature of the child, the entire impulse of the child's mind is, "What is this? What is that? Tell me about this! Tell me about that!" And the child sits artlessly and receives what everybody tells it. It is hungry for knowledge.

Friends, the same thing is true of the human race. I think, irrespective of the theories and philosophies held by human beings, the facts of history will state with louder and clearer emphasis from this time on, that the human race came upon the globe at an extremely low point. Men were created at the very minimum point of humanity—as near to zero as it is possible for human beings to live. Historically, the unfolding of men has been very gradual; and, beginning with very little knowledge and with still less function, they have come up gradually into knowledge of agriculture, of the mechanical arts, of legislation, of manufacturing industries, of trade, of commerce, of civil polity, of organization. When we look at the facts, they are these: That man appears to have been created at the bottom; that God's plan has been to take men at their germinant point—at the alphabet of their faculties—and, little by little, to spell out civilization by gradual instruction, until the present day.

The conflict has not been economical; there has been more suffering than was necessary for the results that have been gained. Men have been ignorant of the causes behind effects; the world has been left to find out the best way it could, and it has been a stumbling way at best; mankind has learned by blunders and tentative processes; the world has lived empirically, and it has stumbled like a blind man; people have made wide circuits when they might with a few steps have traveled the same distance. They have turned again and again upon their own paths, working up by spirals almost endlessly extended.

We Are Bundles of Capacities

Now, it has been like this in every phase of human life that you can think of—in every department of man's effort. Each one of us here is simply a bundle of capacities, depending for his development upon the kind of things he comes in contact with, upon the men he meets, and upon the knowledge which he obtains. That is the real fact, I may say, in respect to nine out of every ten, yes, 99 out of every hundred of the people of the whole world today.

When you look upon men as they actually are, what do you see? Do men start in business wise, farseeing, strong, experienced, judicious? Do not individual business men go into trade and industry, in the vast majority of cases, at an extremely low point, and rise up in development from that low point—subject, for their success, to growth, development, education, unfolding?

Every business has its peculiarities and mysteries, its crooks and turns, a knowledge of which cannot be acquired by intuition. The shrewdest business man will admit, after 20 or 30 years' experience in a certain industry, that, though they thought themselves wise when they embarked in it, they were really very ignorant, and that they have not yet exhausted all the facts relating to it.

Holding to Best Practice

We are all agreed, then, that this is the way business men develop their capabilities; that this is the way they make their enterprises successful: By learning all they can about their business; by study; by applying means to ends; by adopting the best practices in vogue at the present time. Ah! there's where we so often go wrong.

When we go into business we lay our plans on a basis of business as it is then. Whether consciously or not, we assume that things are to remain just as they are now—same kind of railroads, same methods of doing business, same kind of clothes, same kind of machinery, same kind of practices, throughout all the realm of human action.

Of course not, friends! That isn't the way the world is made. The fact is, the whole earth is continually hatching. Spring is on in the business world. There is a development of thought, of commerce—in every form of industry and trade. There are more organizations, more versatility, more and better business methods. All the facts of business, the philosophy of administration, the economic theories applied to the affairs of trade and industry—these are things in regard to which every few years puts the world in a different position. There are continually new facts to be generalized, new deductions to be drawn, new emphasis to be put upon points of importance.

Old Systems Do Not Fit Us

Old systems and frameworks which were wise and good a few years ago do not fit us now. They must be let out somewhere. They must be enlarged in some places and changed in other places. They were admirable for the times in which they were put into practice and for the work which they did; but you might as well go to war in our day with the chariots and horsemen of the old Assyrian empire as to take the systems of the past and with them go into the business conflicts of this later day. The fact is that in many businesses, the old, time-tried policies and methods are just as much out of tune with the times as the prairie-schooners of '49 in comparison with a modern Overland Limited.

"Well," somebody says, "but my business has grown and prospered under old, time-tried methods and plans and policies—these things are proved, dependable, known. Am I going to substitute unknown, untried plans and methods for those with which I am familiar?"

Well, let's see. The highway commissioners of the state in which you live lay out a great road; and when they have bridged the streams, and filled up the valleys, and paved the surface, and marked the dangerous curves, you can travel between point and point with great comfort. But you say, "I have a bridle-path that is more familiar to me than the state highway. True, it is covered with mud in winter and dust in summer, and it is filled up with ruts and chuckholes, but then, you see, I know all about the bridle-path and I am not at all familiar with the highway."

We are like persons standing on the cold steps of this building, with their overcoats and furs buttoned up around the neck, afraid to go in to the warmth and the comfort.

Keeping Up with the Times

Friends, we have to keep up with the times if we would reach the highest possible development in our business. We must constantly improve methods, plans, policies. Now, it seems to me that what we need in business is, not to go back to old systems, or to cling to old methods, but that we should search for these things which stand connected with the development of modern business, and work together on these common grounds.

What are those things? In the first place, right facts and figures guide and control any business. Every business has expenses which are *waste*. It is the money that gets away without bringing any return. This is

the drain that saps the life of the business, and perhaps destroys it. Not always is this kind of expense easily detected, for it may be hidden in the totals. An incompetent or lazy employe may give less in service than he receives in wages; a team or truck may be idle for a day or two; other conditions may be forcing your overhead up where income is less than outgo.

Now, the right sort of bookkeeping and cost-finding makes it possible for you to find the *reasons* for high overhead expenses. Figures will prophesy for any man if they come to him in the right sort of shape. What are my sales? What are my expenses? What is the percentage of expenses to sales? What is my turnover by lines? What is my profit by lines? Where are the leaks? These are the questions that can be answered easily and quickly, if you have adequate accounting methods.

Confidence in Business as a Whole

But there is a larger and more important consideration involved in this question. The day has passed when the individual business man could stand alone. It was not so long ago when trade associations could not reach their highest development because of mutual jealousies. That is no longer the case. New business men are coming to look upon their industry as a whole. Individuals are learning that, irrespective of how well their own business is conducted, they cannot succeed in the long run unless and until the entire industry is put upon an efficient basis. Business men today realize that *confidence* must be centered in business as a whole. They are beginning to understand that what hurts one hurts all; that business as a whole finally regulates their individual endeavors, their profits, their successes.

This being the case, business men are joining hands to do these things together. They are co-operating in establishing uniform accounting methods which assure that all the units shall introduce the same system, and compile their costs in the same way, so that they may be amenable to comparative analysis, and thus make possible the setting of standards.

Thus knowledge of facts replaces guesswork, and uniform accounting becomes one of the master keys to business economy and efficient management. I will make it clear later, by some charts, that a wide adoption of a uniform system of accounting will be a benefit to the co-operating member. Not only is he thus enabled to obtain standards of comparison, but he is also able to obtain the benefits to be derived from a knowledge of how the industry as a whole is moving, which makes possible the drawing of valid conclusions of great practical importance in the management of his own particular enterprise.

Some Graphic Representations

Let me show you a few of the kinds of information that could be furnished to the industry as a whole, if this plan were put into operation. The charts do not cover the entire range of information; they are merely suggestive of the kind of information possible to be worked up.

The first chart is a graphic representation of the total expenses of a given group or of the industry as a whole, together with the various departmental or group expenses that make up the total. This shows the fluctuation of expenses for six months of a certain year. Note that beginning with the month of February all expenses begin to decrease, presumably because business begins to pick up. Now, suppose you could be furnished with information of this kind month by month during the year, could you not gage your own business by this standard of the business of your industry as a whole?

The next chart represents the percentage of profit existing in the sale of all commodities, as represented by the solid black line as well as the margin of net profit earned on specific items. If each man here could compare the profit he is earning with the profit being earned by the whole industry, would he not be in a position to *know* whether his own particular business was about right?

On the third chart we have a graphic analysis of the business of an entire industry for a period of a year. The total sales for the period are shown as 100 per cent; the cost of sales as 70 per cent of the sales; the gross profit as 30 per cent; the total expenses as 20 per cent, made up of groups 1, 2, 3 and 4, showing 4, 4½, 6½ and 5 per cent respectively; and the net profit therefrom as 10 per cent.

Suppose that every man in this association could compare his cost of sales, his gross profit, his total expense, his departmental or group expenses, and his net profit for each of the different kinds of goods sold, with a composite picture such as this? Wouldn't he be able to say definitely whether his expenses were high or low, for instance, by comparing them with the charted results of the whole industry? Wouldn't such information serve as an incentive to reduce expenses in case they were high; or if they were lower than the average, to keep them so? You have heard the story of how Carnegie used to pit one furnace against the other and one plant against the other. The same principle of human nature holds true here.

Let us look at the next and last chart, which illustrates the fluctuation in commodity prices over a series of months. A desire is always present to know the relationship between one's own prices and the prices being asked by your competitors in the trade. If such a chart as this were constructed monthly for each of the different commodities dealt in, it would show you just how your own prices stand in comparison with those being asked by others in the same industry. Information of this kind is of the utmost value to any business man, and all of it could be furnished without divulging the actual figures reported by any single concern, since the information is all worked up in the form of percentages.

Now you say, "That is all very fine in theory, but can it be done?" Perhaps I can answer you more clearly by referring you to what other industries have done along these lines. One of the activities of a certain trade association is to distribute to its members the fundamental statistics of their industry. These consist of statistics of production, output, shipments, unfilled orders, costs, sales, stock turnover, etc.

This association conducts standard cost-finding work for its members. In this work the cost department automatically collects a large amount of information concerning material, labor and burden charges; the relation of profit to capital invested; the turnover of stock and of labor—all subjected to technical analyses, and the ratios, laws and standards set forth and explained.

Another association uses the composite figures reported by its members to set up standards of performance, by which any member may gage the efficiency of his concern. A well-known association of wholesalers has for some time been conducting investigations to determine the relation between turnover and profit.

Such being the advantages of uniform accounting methods, it might be expected that they would be adopted voluntarily. It is not at all uncommon to hear complaints of "cut-throat competition," and to be assured that these competitors are not so much unscrupulous as ignorant. They do not know accurately the cost of the various commodities handled; they have no proper accounting methods, and therefore, especially under pressure, sell at or below cost.

Why not at least insure, by the co-operative adoption of a uniform system of accounting, and the clearing of general information through your association or otherwise for publication, that your competitor shall not be ignorant of what it actually costs to do business. If he insists on being a "cut-throat," let him at any rate sin knowingly and in the pitying sight of all.

Every Business Man a Student

As to a man who is attempting to conduct his business to the best advantage, it is a great deal better for him to know specifically where it is that he fails; where it is that he excels. And he can know this if he has some standard with which to compare his own business operations. Every man in business is a student, constantly studying, constantly learning. The question is, what have you learned? Are you stronger anywhere than you were? Are you better anywhere? Are you gaining? Do you feel as a business man that you be in touch with conditions, both inside and outside, so that you must, day by day, have some means of knowing just how you stand by yourself, and just how you stand as compared with your industry?

If so, then there is hope for you; there is reason to believe that Fortune is smiling upon you. And if you can get information and help from an arrangement such as we have been discussing, isn't it a part of wisdom to lend your support to the movement? Of course this is not obligatory upon you. I declare the right of every man to conduct his business in any way he sees fit, with or without information, internal or external. But—well, I do not attack the great common-school system of the country when I declare the right of every man to get an education without this common-school system.

If a man comes to me for examination, and I find that he knows arithmetic, writing and geography, and that he has learned these lying on his belly before a pine fagot with no one to teach him, am I to turn him out because he did not go through the common school? If he has what the common school was built to give him, that is all I ought to ask. But if you ask me whether I think the common school is where people ought to get an education, I say yes. The common school was designed to extend general knowledge, and it ought to be established and maintained everywhere.

Does not our common-sense tell us that the way to study anything is to go to the center of it? The way to study the continent is to cross it, or go to the heart of it. The best way to study a piece of machinery is not to stand on the outside and look in, but to go in with the engineer and take our place among the belts and the pulleys and the cylinders and the wheels—study the machine as a whole.

Likewise, the way to study our own industrial problems is to do so in the light of the facts of the industry as a whole. There is no perfect individual business; no single business large enough to represent the trade in all its developments. It takes all manner of individual enterprises to do that. Some facts are brought out in one business, and other facts in another business. The individual business is limited. It takes all kinds of business men to make up that composite picture of the industry as a whole against the background of which you can measure your own business as by a measuring-rod.

No man can scoop up to weigh or measure that wonderful efflux of light and heat that comes from the sun, going everywhere and filling infinite space. And yet, if you are in a room, there is only as much light as can get in at your window. But if you go outside, the light will strike you from all sides; you will have an effulgence of light. Hence, if you are wise, you will not coop yourself up in your own individual business, but will place yourself where the light of business as a whole can shine full upon you.

Conclusions

In conclusion, let me say that all industrial disorders are accompanied by a large element of mere talk and wasted time. Instead of trying to remove or improve bad conditions, men talk, or have somebody else, and let it go at that. This is not an indictment; it is merely a statement, absolutely irrefutable. But if we are ever going to do anything, we must make up our minds to do it *now!*

It is at this point that the danger lies; and, as a general rule, I think that "sober second thought," to the average man, almost always deteriorates his best instincts. Men who have in their first impulse aspirations, a lightning flash of understanding, a nobility of purpose when they came to submit it to "sober second thought," rasp it down, take off the color and the beauty, deprive it of freedom and scope, and leave it sordid. Only now and then is there found a man who says, at the first, "I won't," and who, on reflection, changes his mind and says, "I will."

Thousands of men there are who, when duty shines out suddenly, say, "All hail!" who, when some noble objective presents itself, open their arms and say, "Be mine forever!" who, when a field of promise opens before them, say, "I'm going to go into that!" but when they have time to reflect say, "Well, I said I would go, but I guess I'll think about it awhile!" And then they pass it up. Are you, too, going to pass this up?

Discussion of Cost Accounting

DR. BOWLES: I just want to emphasize one point that I mentioned yesterday morning, and that is the importance of keeping accurate figures when you are trying out something new, that is, technical cost accounting. It is a type of cost accounting that has nothing to do with your income tax or determination of your profits directly, but it is important when you are trying out new things to keep exact records of the conditions and costs involved. There is a tendency when somebody starts something new to sometimes over-emphasize its advantages, to exaggerate a little, not knowing exactly what the figures are.

On the other hand, if he is disappointed, there is a tendency for him to over-emphasize the bad qualities of that method. It is very important, I find in my work, to determine what are the exact conditions when you are trying out something new; if you are trying a drag-line scraper instead of a steam shovel, determine the interest on investment between the two methods, the number of tons handled by the two methods and the cost, so that we will get some idea in a general way, of what the conditions are under which each method works to best advantage. That is a type of technical cost keeping that I would like to emphasize so that when we try to work out what are the best methods under certain conditions we have something tangible to work on. If we just have an expression of opinion that this method is better than another, it is like a jury trying to arrive at a verdict without having anything but hearsay evidence, and that isn't very good evidence.

I just mention this because I am continually trying to get a line on new methods and new equipments, on conditions under which they are most successful, and I would like to base the conclusion as nearly as possible on actual facts.

Discussion of Depletion

IRVING S. TUCKER (Connecticut Quarries Co., New Haven): Does the government give you a figure for depletion?

MR. GRAVES: No, it has not. Has it you?

MR. TUCKER: Yes, about half a cent a ton.

MR. SPORBORG: I would say that in 1916 we were audited by the Internal Revenue Department, and the field agents informed us that where the deposit was so large in extent and the quarry purchased long ago so low that the relationship between cost and content was such as to make depletion negligible, that it was the practice then of the Treasury Department to allow one-half cent per ton as an arbitrary figure; and the auditor at that time set up a depletion reserve for us and made such allowance on the basis of one-half cent per ton of crushed stone sold. Of course, you must bear in mind that was in 1916. I have heard since then that some one was called upon to take a depletion account of one-tenth of a cent. It is a fact that the department often overrules statements made by field auditors in setting up reserves in their reports and audits.

MR. SLOAN: We have been allowed 1¼ cents a ton on limestone and 1¼ on sand and gravel in a production that amounts to something like about 8,400,000 tons a year. In our granite quarries we have been allowed 5 cents a ton.

MR. HALL: On what was that based?

MR. SLOAN: It was largely based upon the period of the time for which your deposit can be operated. Each plant, in my opinion, is an individual problem.

MR. HALL: What depreciation do they allow?

MR. SLOAN: Ten per cent on plant equipment.

MR. SCHROEDER: I just want to mention that we are allowed one cent a yard for depletion, and that is not only yards sold, but the yardage that we produce.

MR. GRAVES: Gentlemen, A. R. Wilson, of California, told us at a luncheon the other day that he is able to make a profit by selling ballast to the Southern Pacific at 60 cents a ton and selling them 3300 lb. to

the yard. Now whether or not that is due to a system of cost keeping or due to operating methods, there is no one more capable of telling us than Mr. Wilson.

Cost Summary Sheet Used by General Crushed Stone Co.

I WAS merely going to say that I had noticed with a great deal of pleasure that certain members seemed to be somewhat interested in that cost sheet. I think they are interested because it is the only one here; nevertheless, I noticed some copying down the items which we have, and I have told a number who have been good enough to speak about it that we would be indeed glad to send out copies of our cost sheets, the forms that we use, the methods we use to anyone who would care to take the trouble to send us a letter requesting it, and that will save copying that. If any one is sufficiently interested to copy that, I suppose they would be interested enough to write a letter, and I would be very glad to see that a copy was sent.

PRESIDENT SCHMIDT: This is a very generous offer on the part of Mr. Graves. I understand that there are other people in the room who have some memo-

COST

ACCOUNTS	AMOUNT P. R.	AMOUNT MTL.	PER TON P. R.	PER TON MTL.	REMARKS
GENERAL— Gen. Expense					
Selling					
Int. and Disc.					
Ins. and Taxes					
TOTAL					
OPERATING -Depreciation					
Supplies					
Fuel					
Explosives					
Power					
Bkg. and Ldg. Shovel					
" " " Hand					
Clg. Quarry Reg.					
" " Strpg.					
" " Clg. Lgs.					
Drilling					
Ft. @					
Well Drilling					
Ft. @					
Crushing					
M. & R. Gen.					
Rent and Royalty					
S. & E.					
Stocking					
N. Tons @					
Loading from stk.					
N. Tons @					
TOTAL					
GRAND TOTAL					

	QUARRY CARS	Tons Per Car	NET TONS	TOTAL NET TONS	NET AMOUNT	PER TON	TOTAL NET AMOUNT	PER TON
OUTPUT—Stone Shipped								
" "								
" "								
" Used at Plant								
" Wasted								
" Used M'f'g Am.								
Stone on Hand								
Stone Stocked								
Stone from Stock								
Stone on Hand								
Product—Shovel								
" Hand								
Sundries								

OPERATING HRS. IDLE HRS

REPORT OF PLANT FOR 19

randa; perhaps they would like to get together and compare notes.

MR. WILSON: I think, Mr. Graves, that possibly I had better wait until some other time this afternoon. There is one important point that I want to make and that is this: I believe that this association should have an accounting department, something that will develop uniform accounting.

I would like to read to you what occurred in the San Francisco Contractors' Association, or, it is technically termed the Contractors' Association of Northern California. They had a convention similar to this one—of course, much smaller—about three weeks ago, and they took action on two important subjects; one was an engineering department and the other was cost accounting. Many of the contractors in California have gone broke during the last ten or twelve years in trying to build highways for the state of California under conditions and specifications that were very unfair to the contractor, and many contractors went into the business not knowing the cost data, not understanding the cost, in many cases, of getting water to the job for concrete roads, and other items that entered into it; so the contractors' association decided the best thing to do was to have a uniform system of accounting, so that all the contractors, either members or not, could have access to these sheets so that the contractors would be less liable to leave out the important items. It was a very short time ago when a contractor, whenever he got a job, would figure around and say, "Well, what did I leave out?"

I will just read this to you, Mr. Chairman.

"At a recent meeting in San Francisco the Contractors' Association of Northern California voted to establish engineering and accounting bureaus whose purpose will be to aid members in keeping the cost of doing work to a minimum and securing general use of uniform accounting systems.

"The association has about 70 members who are engaged chiefly, or at least partly, in highway construction, and it is chiefly to this field that the activities of the new bureaus will be devoted.

"Members are to be charged for any special services rendered by these bureaus which are thus to be made self-supporting, if possible. However, to start the plan, the association has authorized the annual expenditure of $10,000 for the Engineering Bureau and $6000 for the Accounting Bureau. This will make available for all members high-grade services at a cost less than could possibly be secured if members independently retained experts in these two lines.

"The Engineering Bureau will check over specifications to warn members against conditions and requirements that may be to their disadvantage. Second, make field examinations and reports covering sources of materials, etc., on all important road jobs on which bids are asked. Third, make cross sections and otherwise check figures and estimates of state or county highway engineers on contracts awarded and during the progress of construction, serve on call as engineering consultant to the contractor, particularly in disagreements or disputes, and, fourth, to represent the association in conferences of hearings where expert engineering opinion is required.

"The Accounting Bureau will first canvass and inspect the accounting systems now in use by members and will then compile an accounting system that can be applied by all members to their highway contracts. The bureau will then endeavor to secure the general adoption of this system by members and also by the state and county departments insofar as this will aid in reducing the cost of compiling, analyzing and comparing estimates on work offered for contract."

I think, gentlemen, that a cost accounting bureau would be a very fine thing for this National Crushed Stone Association, so that we would all be on the same footing, and, as explained by the speaker, that we would understand and be able to apply the other man's cost figures to our work and to look for leaks.

Ballast Business in California

Mr. Graves spoke of our selling ballast for 60 cents a yard of 3300 lb. It is not 3300 lb., it is 3000 lb. to the cu. yd., but we don't care about the cu. yd., we sell it by the ton (60 cents) entirely. We sell that ballast to the Southern Pacific Co., on the coastline, and they take our surplus; our capacity at the plant is about 2300 tons for 8 hr. Now there are many times during the year when our commercial business is not large enough to use that demand, so then we go to the chief engineer in San Francisco, and he will lay out a ballast program to use that surplus. We can, therefore, afford to sell it at that price.

Our quarry cost last year, including all items of that cost, was 41 and a fraction cents per ton of rock delivered on the cars, including hydraulicking. We remove the overburden of 40 or 50 ft. by means of water pumped up from a river. Some of it is too hard to wash, so we have to shoot that first. We wash it down and have to blast the ledge. Last year we put the rock on the car for 41 cents. That is the highest cost we have had for several years, but we are paying higher wages now.

MR. SPORBORG: Do you mean you have 40 ft. of dirt that you remove hydraulically?

MR. WILSON: We have between 40 and 50 ft. of all kinds of dirt, some of it is very hard clay, some of it is old beach, has clam shells and other evidence of beach; as I said before, some of it is so hard that we have to blast it.

Merchandising Crushed Stone

By George E. Schaefer

District Sales Manager, General Crushed Stone Co., Rochester, N. Y.

SERIOUSLY, we do not feel that our method of selling is the best and only way. Far from it. However, we have existed for some years on the basis at present in effect, and we are pleased to offer it to this convention for what value it may have to you. Moreover, we are also vitally concerned in becoming conversant with better and newer business methods, and possibly this interchange of thought may result in a betterment of conditions to us all. In that event, it will have been worth while.

To the average layman, the selling branch of a crushed stone industry has no especial significance. Even the wise old sage who sits on the cracker barrel at the country store, who governs the destiny of the universe and knows all things—even he is sometimes in a quandary to adequately describe a "rock peddler." But to those of us who know that our product is an important part of that great system of railroads that girdles the country, is an essential material in the Nation's wonderful network of highways, and is disposed of annually in millions—aye, hundreds of millions—of tons, the greatest of pride in a great fundamental occupation is no only justifiable but indispensably necessary. You will note that I say "disposed of," for it is the selling end of the business with which we will directly deal in this treatise.

The sales organization of even a stone company is not devoid of complicating and interesting features. Who of you gentlemen cannot conceive of the complications arising from consigning a carload of stone to Newark, N. Y., and having it land in Newark, N. J., nor of the difficulties involved in shipping a carload of a supposedly certain size and having it arrive at destination with an entirely different lading. Moreover, we are all unfortunately aware of those distressing times when we are forced to endeavor to distribute the output of certain sizes to a hungry insistent market demanding at least three times the quantity at our disposal. Only bins endowed with the qualities of the miraculous pitcher could materially assist us under such conditions. Oh, yes, even we are "fellers" who occasionally "need a friend."

Quotations

Too much stress cannot be placed upon this important feature of selling. Quotations should always be in writing and where rendered verbally, always confirmed in writing, either by letter or telegram. If by telegram, this also should be confirmed by

letter. In every possible case we make them applicable to the particular project involved, and where competitive bidding takes place we invariably lengthen the time of effectiveness of the quotation to include 10 days from formal award of contract, at the same time specifically stating that it becomes null and void unless accepted within that period. The principal purpose of this policy is to eliminate the somewhat dangerous obligation to supply material at an indefinite future time when subsequently accepted quotations may have absorbed the production. There is also the possibility, even though remote in our business, that the selling price may rise, and the quotation for a specific length of time is a precaution in this regard as well.

Credit of Customer

When we ascertain the name of the low bidder or the one to whom the contract is awarded, it is our practice to investigate his financial standing and reliability. This applies particularly to new firms or strangers, for our past relationship with most of our old customers renders such action unnecessary. We not only directly refer to Dun's or Bradstreet's, but make it a point to find out how they are rated in their own community, their past and present relationship to other firms, highest credit, and such other information as is useful in assisting us to determine to what extent it is wise for us to advance credit. Data of this nature is easily obtainable from many different sources, and in the turbulent period of the past two or three seasons such knowledge was very often indispensable to us for our own protection. Of course, on municipal work, awards of contracts are seldom granted to other than responsible bidders who are under bond, and who are not bonded unless they are responsible, and, as a last resort, on New York state work a lien can be placed on the job. Ultimate payment of the account, in such instances, is reasonably assured, but at the same time it is just as well always to "know your man."

Terms of Sale

There are so many satisfactory terms of sale that it is unnecessary to do more than offer the following printed statement we use on our quotation forms:

Quotations are made for carloads f.o.b. cars seller's plant, subject to railroad company's weights and rules, and to prior sales and change without notice except when made to cover specific work, and are effective for ten days from date unless this time is extended by special agreement in writing. Delivered prices are quoted only for the convenience of the buyer, the responsibility of the seller ceasing with proper delivery to the carrier. The buyer is liable for any increase in freight and shall benefit by any reduction as the freight rates may be advanced or reduced. The buyer is also liable for any taxes on freight.

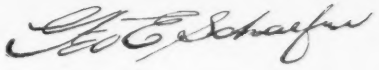
Orders are accepted subject to delays due to strikes, accidents, shortage of cars, labor, fuel, or material used in manufacture and production, to the exigencies of war, and to all other causes beyond the control of the seller.

Invoices for prepaid freight must be paid immediately upon presentation.

Should the buyer's credit become impaired or payments delayed beyond the terms specified, cash may be exacted or shipments discontinued and order cancelled at the option of the seller.

Terms: Cash by the last of the month next succeeding shipment.

These terms are sufficiently definite and specific as to require no further detail, other than to state that to make them doubly impressive, we insert in the body of the quotation the typewritten phrase that *"this quotation is subject to the above printed terms of sale."*



Discounts

About three years ago we established a discount system on payments of bills, and, to quote the words of our treasurer, *"We never made a better move in our history."* There is absolutely no question of its merit and usefulness in facilitating payments and settlement of accounts, and, while there were occasional difficulties for a short period immediately following its inception, it is now quite generally understood and acceptable to the trade. We allow a discount of 10 cents per net ton *if all overdue invoices are paid* and payment is made by the 22d of the month next succeeding shipment. Except in the most unusual cases, we *do not* allow the discount if payment is made after the discount period expires. Our consistent refusal to permit customers to take advantage of this allowance after the discount period has expired caused, in certain cases, some antagonism and irritation, but it soon became clear that the whole principle of the plan would be defeated if exceptions were made, and that fairness and justice demanded an impartial application of this rule.

It has not been difficult to convince the occasional delinquent customer who demands that the discount period be extended in his case, that his contention is not sound and should not be granted. In the few cases where the discount was deducted by the customer and the net amount of the bill paid after the discount period had expired, we immediately tendered a second invoice for the amount of the deducted discount and in each case this additional amount due has been collected without any particular trouble. For certain reasons, particularly because of the manner in which estimates and price proposals are treated, we have quoted and invoiced the State Highway Department during 1922 at a net price. While we regretted the apparent necessity of making this exception to our discount policy, conditions were such as to render such action on our part advisable. Our past three years' experience has led us to believe that the discount method is distinctly beneficial and should be more generally adopted.

Acceptance of Orders

Our usual manner of accepting orders is to do so in writing and if the customer places the order verbally, we ask his acknowledgment of our acceptance so that we may know that the conditions are properly understood. During the peak period of production and demand we are often asked to guarantee a definite number of cars per day. Generally we cannot guarantee anything, but reply that under normal conditions we can render the desired service. In those cases where we do bind ourselves to *ship* a definite number of cars per day, we require the consignee to obligate himself to *receive* this number of cars per day, as it is only fair that a mutual obligation should exist, and that if we properly undertake to ship, the customer should correspondingly undertake to receive. If this is not definitely understood, it is perfectly obvious that possible, if not probable, occasions will arise whereby the consignee requests a suspension of shipments with the resultant necessity on the part of the producer to seek other disposition, thereby obligating himself to extra shipments. Then, when the suspended shipments are again requested, he finds himself unable to meet the increased demand into which he has been forced to enter as a matter of self-protection. Naturally and reasonably there must be some pliability in such an arrangement with a willingness on the part of both parties to be governed by each individual case and to adapt themselves to whatever exigencies may arise, but the mutual responsibility to ship and receive shipments should be acknowledged by both.

Prepayment of Transportation Charges

This temporary expenditure of ready funds is something which every stone company should seriously consider, for if neg-

lected it will obligate a large sum of money with no return. We sell all of our material f.o.b. cars quarry, and discourage as far as possible any request of the consignee to have us prepay freight. When deliveries are made to a siding or station with no resident agent it sometimes becomes necessary to prepay the shipment, but even then we endeavor to have it handled by the customer through the railroad agent having jurisdiction over the unloading destination. If we do advance the freight charges, bills are rendered immediately and payment is demanded promptly. We have occasionally prepaid freight charges where the unloading point was far removed from the site of the construction and it was extremely inconvenient for the consignee to make daily visits to release the cars. In such cases we have sometimes asked for and received 6 per cent for the use of our money.

Disposition of Full Production—Necessary Storage

This is the bug-a-boo of the stone man, for few of us dispose of our entire production at all times. We all know that the least saleable size is screenings from ⅜-in. down. The demand for the other sizes reaches its peak at various and different months of the season. Experience over a number of years with nine different plants has convinced us that the demand for ½-in. stone or dustless screenings is practically constant throughout the active operating period. Where ballast is produced, this is equally true with the exception of early spring and late fall when recrushing is sometimes necessary. The heavy demand for top course stone, called 2-in., or No. 3, comes during the late summer, and at this time we usually exhaust what stock we have necessarily stored during the earlier months. In some localities the 1-in. stone, or No. 2, is not readily saleable at all times, and it becomes compulsory to stock or waste this size. There is, however, a demand for a goodly tonnage of this before the quarry opens in the spring and also after the annual shut-down.

The Sales Department should be governed largely by the prevailing conditions at the quarry, and should always have uppermost in mind the acceptances of orders only of sizes commensurate with the plant production. Too few of us give this the serious consideration it merits, but it is very evident that with the same overhead a plant that disposes of 80 per cent of its output is far ahead of one that disposes of but 60 per cent. In our own case the percentage of the output disposed of varies with the different plants and changes slightly year to year. In 1921 for the three New York state plants combined, the stone sold was slightly more than 84 per cent of that produced.

The seasonal operations of those plants in New York state which are under my immediate sales supervision generally run from the latter part of April to the latter part of November. Our Pennsylvania and Massachusetts quarries, by reason of their geographical locations, have a more extended period of activity. During the winter months, or rather in the interim from shut-down in fall till resumption in spring, we sell a considerable amount of stone from stock. On such sales we receive an additional 25 cents per ton to cover the extra costs.

Prices

Prices naturally will vary in relation to the overhead and operating charges, and it is not our purpose to discuss this feature other than a uniformity of prices on the different sizes. There seems to be a prevailing idea among producers that the selling price on all sizes but screenings should be the same, with the latter somewhat lower in price to stimulate additional sales. Perhaps this is so, and it is not for us to make suggestions in this regard. We feel, however, that as far as we are personally concerned, prevailing conditions in each individual sales territory should constitute the governing factor, and that flexibility is advisable if the particular case should warrant. It is also extremely essential to have it distinctly understood that a slight per ton reduction in one or two isolated cases by no means establishes a new general scale, for the deterrent reaction sometimes takes the form of a "boomerang" with disastrous financial results. Then, too, there is the question of somewhat reduced quotations in early spring and late fall, when business is usually at a minimum. That this may excite sales is true, but the advisability of the method is doubtful.

Collections—Protection of Accounts

While collections of accounts are more largely the duty of the Treasurer, they are, nevertheless, so closely related to Sales that a word or two on this subject is not amiss. The Sales Manager knows his customer and should keep a watchful eye on monthly shipments, and also, if possible, on the prosecution of the construction work. He also knows whether or not bills are being paid regularly, and his recommendations to a great extent affect the activities of the financial department. If conditions are bad, it is well not to wait too long in taking action for the protection of the account in question. Sometimes a cessation of shipments will answer the purpose, and again it becomes necessary to resort to legal action. Liens and assignments give adequate protection if registered on time, but notes are hardly acceptable except in widely scattered cases. Almost every company periodically has bad accounts which tax one's patience to the limit, and it is essentially the duty of the Sales Department to use the greatest tact and diplomacy to obtain an amicable and mutually satisfactory settlement.

Delayed Deliveries—Overshipments

Who of us has not faced criticism, and occasionally even abuse, because of delayed deliveries? We promise to ship at a certain time and actually do so, and then for some unaccountable reason the consignment does not reach destination for a week or two after date of shipment. Rather than hold up a contract, and, though entirely innocent, face the censure of the consignee, we load and dispatch a replacement car to help him out of his difficulty, and when the delayed car eventually reaches destination the work may be completed, the lading may mean an overshipment, and consequently the car is refused. Then we face the necessity of acquiring other disposition at a financial loss to release it. We cannot suggest a cure for such difficulties at this time, but it seems unjust to blame us for something undeniably beyond our control. The only redeeming feature of this condition is that it is not of frequent occurrence.

Advertising—Commission Sales

There are a great many forms of advertising in the stone business, as well as any other, and it would seem unnecessary to go into detail on this subject. As we are giving you our methods of selling material, however, it is incumbent upon me to say that we do no advertising whatever, and this because we feel that the cost would be disproportionate to the results obtained. In common with others, no doubt, we were in the past, somewhat more so than at present, continually requested, and at times beseeched, to place advertising in all sorts of magazines, papers, pamphlets, and programs, as well as engineering and trade journals. These requests would come from village, town, county, and state publications, fraternal organizations, brotherhoods, unions, local charities, and organizations of various kinds, their pleas being based on our operating somewhere in their vicinity or selling stone in their territory, or shipping over a certain railroad, or in some manner endeavoring to tie their requests to our material interest.

Infrequently, but occasionally, there has been the implication, even though well concealed, that if we refused to advertise, retaliatory measures might be taken. In such instances we have felt that this was merely the ill-advised thought of a particular individual and did not properly exhibit the sentiment of the municipality or organization which he was representing, and in no case, so far as we know, has our refusal to advertise been followed by any retaliation whatsoever, in any shape, manner or form. Our operations are in three different states, shipping into seven states, over some 13 different railroads, so that it is apparent that we come in contact with a large number of cases of the kind we have just enumerated. We have estimated that if we advertised in all the journals and publications brought to our attention in this manner, the expense to us would run somewhere around a hundred thousand dollars, and we utterly fail to see that the additional stone sold from such advertising could possibly be in

any manner commensurate with this investment.

Some companies also market their product by commission forms of sales—such middleman (if I may use this term) retailing the stone on a basis of a certain number of cents per ton. Again, to quote only our own method, we handle all sales ourselves through district sales offices, and have no representatives other than those solely in our employ. We feel that for many reasons this is distinctly advantageous to us, and we see no necessity at this time of modifying this method.

Personality

There are a number of other items in connection with selling which cannot be enumerated in detail, but I cannot refrain from mentioning, briefly, the importance of personality. We have found it extremely desirable to be in attendance at meetings and conferences of officials with whom we deal. We gather and file information in relation to future designated projects. We take an interest in the construction work in which our material actually is used, and render what assistance we can in facilitating deliveries. In short, we believe that personal contact goes a long way toward maintaining a friendly and satisfactory business relationship.

To those of you who hold a position similar to my own, and in whom is vested the responsibility of merchandising our product, I would say unqualifiedly that yours is an important work. Without wishing to detract one iota from the importance of the producing branch with which we are indissolubly associated, it is, nevertheless, conceded that crushed stone may be produced until Doom's Day, but unless it is disposed of properly, such record production will be of no avail.

The Sales Department of a stone company can, if it will, materially benefit the business as a whole. In like manner, and as the result of improvement in the case of the individual will this National Crushed Stone Association be materially benefited. Let us look at it in that light and let us realize that in doing our "bit" in our own best individual ways with co-operation and loyalty, we also do our share towards placing this National Association on the plane where it rightfully belongs—a respected, honored, and powerful spokesman of a big, basic, progressive American industry.

Special Uses of Crushed Stone

By John J. Sloan
Secretary, Wisconsin Granite Co., Chicago

THE numerous special uses of crushed stone do not in volume constitute any appreciable percentage of the total production as the markets for flux, ballast, macadam and concrete construction absorb 90 per cent of the quantity produced.

In addition to limestone being used for fertilizing purposes, you are familiar with its use in small granules of two distinct sizes: one for laying hens and the other for baby chicks; also its use in the various calf meals, where it is mixed in certain proportions with feed in order to afford the necessary lime for bone-building purposes.

You are also familiar with its use as an asphalt filler for pavement work when ground to 200 mesh;

Its use in the rubber industry as a filler when ground to 300 mesh;

Its use when meeting certain high calcium tests in the sugar industry and in the various carbide, alkali and other chemical processes.

Likewise the quantities that are used in the glass factories and paper mills;

As a filler in whiting and in paints;

As an addition to organic fertilizers.

Where it has certain oxidized colors it is used in small, carefully screened sizes for stucco and terrazzo work.

There has been a heavy demand for the heavily stained, weather-worn, thin slabs of limestone in building and wall construction in various sections of the country and many pretty artistic effects are being produced with them.

In harbor construction and shore protection large quantities of crusher run limestone up to 6 in. is used in many places to build great cores that come within a few feet of the surface of the water, and then along the slopes of these cores as well as their top is placed with 5-ton pieces of granite or other hard rocks that will resist storm, ice, and erosion.

Last, but not least, large quantities are burned into lime which in turn forms the base for materials produced with it that are used in a thousand lines of industry that range from steel to soap.

In the granitic or siliceous rocks those that are highly colored have when crushed and carefully screened to small sizes a limited market for stucco, terrazzo and dash work.

Within the past year two plants have been erected in this country that I know of for the manufacture by fusion of various-colored siliceous stone, which is then crushed and screened to sizes for pebble-dash, stucco, and terrazzo work. The colors on test have proven quite satisfactory and they are able to produce at will any shade called for. On account of the greater uniformity of color and wearing qualities this material, if found on extensive tests to hold its color, will prove a serious competitor to the stone men in this line, and I would advise against any extensions in the production of this class of material until the future of this artificial product is determined.

The finely pulverized material when tube-milled can be used as a filler in mastic floors.

For septic tank systems and sewage disposal basins, hard aggregates ranging in size from 8 down to ½ in. have an increasing use, and with the growth of population in the country, and the efforts being made to prevent the fouling of our streams, this method of sanitary disposition is constantly increasing.

Granite and quartzite blocks are being supplied these days for tube-mill linings. The same material is being used in lieu of pebbles not only in cement but in many mining centers where the flotation process for the recovery of ores is now used, necessitating fine grinding and the use of material that is inert, and which would not form any chemical combinations in opposition to that used in the treatment of ores.

Sandstone, containing a certain percentage of clay and aluminum, making it practically a natural silicate of aluminum, is used in the form of blocks for lining blast furnaces and other places in the metallurgical trades, where its ability to withstand a temperature of 3600 deg. F. and upward, renders it superior and much more economical than a high-grade firebrick.

Quartzite and granite screenings are likewise used in the steel mills for the lining of kettles, constant repairs, and replacements to silica brick linings, which is likewise a product of silica rocks, of upward of 96 per cent content.

In the oil fields, heavy asphaltic oils are now treated through towers lined with an extremely hard resistant rock ranging practically 80 per cent in silica, and in various other systems of treatment for filtering the crude oils before the cracking or distillation process begins.

Similar granitic rocks are used for curbing, flagging, and paving blocks of various sizes and shapes.

In crushed rock it is used as a wearing surface to armor-plate countless miles of road annually, either in cement or bituminous concrete form.

The bulk of crushed granite is produced as a waste material incident to the cutting of stone for buildings, monuments, paving blocks, etc. In addition to paving, it finds its market for curb and gutter, sidewalks,

surfacing, and scores of places where severe stresses must be met and hard wear withstood.

In sulphuric acid towers, acid-resistant floors, various chemical apparatus, harbor improvements, rubble-mound breakwaters, rip-rapping and shore protection on the oceans, Gulf and Great Lakes shores, as well as river protection in fast-flowing streams—all consume quantities of hard rock which must withstand the stress of storm and be proof against constant freezing and thawing.

From 10- to 15-ton units down to material to a 300 mesh—which latter is also used in the roofing trades—as well as in the soap and cleansing compounds, there are places being constantly developed for the use of all sizes between.

Of course the volume is small as compared with the ordinary uses, but in a growing country like ours, with marked initiative toward improvement and bettering existing methods of carrying on our various industries, there is a promise that as the days go by the market will be extended.

Selling Stone and Crusher Sand

By R. W. Scherer
Western Lime and Cement Co., Milwaukee, Wis.

TO begin with, let me explain the term crusher sand—sand produced by crushing stone, not screenings. The term "screenings" is derogatory; implies a waste or inferior product. Crusher sand is not an inferior substitute for bank sand; far from it. It is not only as good, but better. And the title makes a difference.

The laundry operators of the country could not induce many people to have their clothes mangled. They decided in convention to call it flat-ironing. The new name stuck and flat-ironing has become a big part of the laundry industry. More recently sausage manufacturers have made an effort to rid their pet product of its opprobrious epithet "hot dog," knowing that by any other name it would smell as sweet and perhaps sweeter.

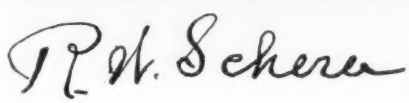
Whether they can make us adopt a new designation for Fido in his last useful stage remains to be seen, but we can make "crusher sand" the universal term for the best part of our product. The very name screenings has cost us 25 cents a ton since the beginning of the crushing business, because in our own minds we have classified our product into stone and screenings—the product and the waste—the wool and the shoddy. It is all wrong. Let us make it a misdemeanor to speak of "screenings."

Stone Salesmen Must Know Stone

A thorough knowledge of stone is as indispensable to the stone salesman as tools are to a carpenter, and I want to urge the efficacy of scientific tests. Stone everywhere has to compete with a very much cheaper substitute. To get the higher costs of stone, we must show we have a superior article! We have.

There is one best way to prove it to the men we have to deal with, and that is by means of dependable test. The engineers and architects who are to specify stone are scientific men and they must have tests. They cannot afford to put up a building and have it fail in order to find out that the material was no good. Concrete structures have failed, but seldom, if ever, has the cause of failure been satisfactorily determined. In fact, cement content or clay content of concrete cannot be determined by any known method of chemistry after the concrete has once been cured.

Other things being equal, crushed stone concrete is about 50 per cent stronger than



gravel concrete. There are reasons and there are proofs. The reasons are that crushed stone has no water-worn surface bonding the surfaces more thoroughly with the mortar, and that it is angular in shape. The proofs are to be found only in tests.

Sales Value of Tests

As stated, this is the case if other things are equal, but it is rather difficult to determine when these other things are equal. You might go about making tests; you mix in the one case four parts of stone, two of sand, and one of cement; in the other case four of slag, two of sand and one of cement The same measures by volume the same sand and cement, and you think you have handled stone and slag alike. Apparently you have, but the fact remains that in the case of stone you got 5 to 15 per cent more concrete than with the slag. Hence there is more cement in a cubic yard of the slag concrete than in a yard of the stone concrete and your comparison is unfair.

Similarly, a well-graded crushed stone, a real crusher run, ranging in size from ¼-in. to 2-in., will make more concrete than a poorly-graded one, one that is all fines or all coarse stone. And right here crushed stone has an enormous advantage over gravel. We can furnish graded aggregates; we don't always do it, but we can furnish well-graded mixtures and should do so and get due credit for the advantage.

Crusher Sand

Crusher sand—almost any granite, limestone or trap rock sand can be sold anywhere if you are willing to meet the price of bank sand. Of a great many samples on which I have data, not a single one failed to show tensile strength equal to that of the best bank sand. Only one specimen, crusher sand from a soft sand stone contained sufficient dust to weaken the mortar.

As to tests, a large mass of figures are available from all possible sources, and invariably, they are higher for crusher sand than for natural sand. But it is still necessary to have tests made of your own sand. Don't be afraid of them; almost any limestone crusher sand fairly free from clay will show up stronger than the best of bank sand. But it is best to compare both crusher sand and bank sand with the standard Ottawa sand. A good scheme is to let the engineer who is to be converted, make or order his own tests in each case.

Besides tests I have used two other selling arguments, both rather more convincing to the layman than the tests, and these were, first, a screen analysis of the sand in question showing the various sizes contained in crusher sand and explaining the reasons for the denser and hence stronger mortar. The reasons are briefly that 20 per cent of 100-mesh material in fine aggregates is absolutely beneficial, helps the cement to fill voids, reduces the thickness of the joints between particles that must

be glued together by cement. Cement is the glue and the smaller the joint the better it will glue.

But better than the tests or the theory is an examination of the mortar briquettes themselves. Even a casual examination will leave no doubt which is the better mortar. If you have tensile tests made save the broken briquettes; they are a better argument than the tests.

Crusher Sand in Concrete Pavements

All of this refers of course to structural concrete or concrete base under some other type of paving. The question of using crusher sand in the wearing surface of concrete paving is another story. But here, too, we have had some success and can hope for more. Some years ago when I was making a more exhaustive study of the subject, H. E. Breed, former chief engineer of highways, New York State, wrote me that: "The department is now using screenings on several highways as a substitute for sand for fine aggregate and although it is too soon at present to decide that this mixture can be used to a large extent, under present conditions we find we are justified in making this substitution in order to try and utilize stone screening which on concrete roads, using local stone, is a waste. We find extreme care is necessary in using this product and if any recommendation was at all given for the use of stone screenings, it would be under the conditions of expert inspection."

The Cline road, Indiana Harbor, Ind., one course concrete, is entirely crushed stone and crusher sand, and I have never seen better concrete. However, the mixture is 1:1½:3 and we must prove our case for a leaner mixture. There are other examples near Chicago which could be enumerated and which are uniformly successful.

In Wisconsin I have got away with a small test piece that is all crusher sand and a five mile job where it was mixed 50 50 with bank sand. Wisconsin engineers are ready to use crusher sand the coming season without other fine aggregate, though under careful inspection and after thorough testing of the sand in question.

As to Washing the Stone

Another and very important question is answered by the same consideration, the question of washing crushed stone. It is proposed to remove the dust coating of crushed stone by washing. Now for many years, in fact, ever since cement has been studied, investigators have tried to determine the best proportioning of fine aggregates. By fine aggregates is meant material passing through a ¼-in. square mesh. This material was divided into three sizes. The coarsest down to 20 mesh, the medium from that to 50 mesh, and the fine from a 50 mesh to impalpable dust. The results of all possible mixtures of these three kinds have been tabulated, and it is found that in mortar mixtures 70 per cent of coarse, 10 per cent of medium and 20 per cent of fine, result in the greatest tensile strength of the mortar.

Now all these tests are made with mortar only; no tests are available of finished concrete, that is coarse aggregates plus mortar. If course aggregates are added, it seems to me, that the percentage of medium and fine necessary to gain maximum strength must be proportionately increased, so that in actual concrete (not mortar mixtures) 25 per cent of 100 mesh would be beneficial. The 100 mesh material is dust and 20 per cent of it is beneficial to the mortar. Why remove?

The objection is raised that the dust coats the stone and prevents a bond. Personally, I believe that no dust coating on stone would survive one turn of a concrete mixer. If it can survive, washing will not remove it. I have examined a great many quarries and their product, limestone, granite and trap; I have yet to see one whose product would be benefited by washing. Unless there is clay in the deposit that cannot otherwise be kept out of the finished product and if it is proposed for the purpose of removing dust, it seems to me that washing crushed stone is utter folly.

On this as on every subject that I have touched upon there is a vast field for further research. Alone the tabulation of investigations in all states, the interchange of news between association members and communication of the results of tests as they are undertaken and progress would benefit us all. I hear that the state of Pennsylvania permits only crushed stone in one-course concrete and have recently read the complaint of a gravel man that New York State gives preference to crushed stone, and I would be very much interested to learn why this is the case. If we can enable our association to conduct such investigations and such a clearing house of information, it would redound not only to the benefit of every member, but to the good of concrete and concrete paving. It would be a lasting public service.

Discussion of Selling Stone and Crusher Sand

RUSSELL RAREY (Marble Cliff Quarries Co., Columbus): I would like to ask Mr. Scherer whether or not material, or sand, either manufactured or natural, containing as much as 25 per cent of 100-mesh material will pass state requirements.

MR. SCHERER: Well, it depends on the classifications. The thing to do is to make it pass. Show by tests that it will stand up. The fact that 20 per cent of 100-mesh material is beneficial to mortar mix was rather a shock to the investigators; positively nobody at that time explained, but the fact is there, still.

Along this line I would like to add that 20 per cent attains maximum strength, that variations from this 20 per cent up or down weakens the mortar, so that 0 per cent of 100-mesh is no stronger than 40 per cent of 100-mesh.

MR. RAREY: We size our limestone sand in keeping with the present-day accepted specifications, which are not to exceed 5 per cent in some cases and not to exceed 3 per cent in other cases of 100-mesh stuff. The few tests we have made indicate that if you approach 5 per cent of a 100-mesh you get a greater strength, and if you go above or below that you weaken the concrete. Those have been the tests that were made by the Ohio State Highway Department on a one-three mix.

MR. SCHERER: There may be other factors in that, but the highest authority on cement concrete in the land is a committee of five of the American Society for Testing Materials, which some years ago issued the edict that 30 per cent of 50-mesh was permissible.

MR. RAREY: Well, of course, 50-mesh and 100-mesh are different make-up. One is dust and one is grit.

We can make our product conform to state specifications. We can use it in any engineer's specifications in Central Ohio, and the success of the operation might be best illustrated by saying that we recently put in 40,000 tons of our washed stuff in the Ohio stadium without any part of it being rejected.

MR. SULLIVAN: I would like to ask if Mr. Scherer's remarks applied only to limestone sands.

MR. SCHERER: And all other sands.

Selling Agstone

I FOR one would like to see the price of limestone go to the place where the price of it would put a man actively in the field getting orders. I know that this winter I have convinced enough men in Indiana that they need limestone to take it all out of one or two of our quarries, but I don't believe those quarries are going to get the orders because they are going to have all winter long to get cold on the proposition. They are going to have six months to find some excuse why they shouldn't use it. We appreciate the slowness that farmers do things by themselves. They will work in groups. We have seen that demonstrated all over the United States.—Prof. A. W. Ostrander, at the Agstone luncheon.

Merchandising Crushed Stone Products

By Harry H. Brandon
Ohio Marble Co., Piqua, Ohio

IN my remarks on salesmanship I expect to report my observations and experiences in my efforts to develop agricultural limestone sales.

The first requirement is: A sales department must have something to sell. It cannot by magic transfer some worthless substance into *cash*. It is with this thought in mind that I strongly urge the immediate installation of an efficient bureau of research.

Before a sales organization can function to any degree of success, the manufacturer must prepare a product that has a value and a purpose. This product must be prepared in such a way and at such a cost as to permit its being economically used, and in such location as to be readily accessible to a market already developed or where the possibility exists to develop a market.

In the instance of bulky commodities such as crushed stone products the location plays an important part. If a location is found that qualifies with regard to market, and competition is not particularly strong, the quality of manufacturing may not play such an important part, but this is a rare condition. Usually competition is keen.

It is unfair to expect a sales organization to market successfully a deficient product in competition with efficiently prepared materials of other manufacturers. It is sure failure in the end. A salesman may take the first order, but the second will be more difficult, and a third or fourth impossible. I have just mentioned these few things to indicate that the sales organization is not the only department of a business that needs keen and ever alert direction.

Salesmen and Sales Organization

Now for the part played by salesmen and sales organization. I believe the same general principles of salesmanship apply in all commodities. Be it limestone or shoestrings, there are certain stages through which our prospective customer must pass. Most salesmen, irrespective of what line they represent, seem to be of the idea that they are the ones who really accomplish a sale, while actually in the majority of instances they are what might be termed the "closer up."

Some of my remarks may give the impression that I am trying to minimize the value of the salesman, but such is not the case. I hope to locate the dividing line between the possibilities and duties of the salesman and the absolute responsibility of the sales manager or home office. A great general will not send his infantry into the field without a carefully planned campaign, the proper support of artillery, etc.

Your salesmen represent the infantry of the army and are quickly and easily "shot to pieces" unless they act as a part of a well-designed and executed program. They should not be sent into a market until it has been prepared for their attack by the sales management. If their market is not properly prepared, success is slow and uncertain. *More salesmen fail because of poor sales managers than of personal inability.*

Can you imagine the time and expense incurred for a salesman to originate and

Harry H. Brandon

carry a single sale through all its phases—interest, desire, selection, decision, and action? In many instances the sale is already made before the salesman arrives and in almost every instance at least the first two stages of the sale have been accomplished before the arrival of the salesman.

This fact was most conclusively brought to my mind when I attempted to sell limestone to grain elevator, building-supply dealers and others in Western Ohio. I do not believe the salesman could have accomplished this feat a few years ago.

Selling on Value and Possibilities

I have approached a great many dealers and have sold them completely on the value and the possibilities of limestone. I have sold them to the extent that if they were farmers they would have bought, but as business men who had never in their business history had one individual farmer ask for limestone, it was a different proposition.

I remember running across one elevator man who had bought a car of limestone and put it in stock. It had been there three years when I called. The minute I said limestone, he was ready to fight. His money and storage space had been tied up for a great length of time and he had not been able to dispose of his product. The sales management had not prepared this market. The company who shipped his order—by the way, they are out of business now—was not well organized in salesmanship. They simply unloaded, on an unthinking man, an article for which he had no use, and incidentally made an enemy.

I went into this community and with a short intensive campaign sold enough limestone religion to dispose of the limestone this man had in stock, and now he is our best friend and sells a few cars each year, but never carries limestone in stock. We have not developed his market sufficiently to justify this, but he and we are working together and expect to develop it further.

A few of these experiences taught me that salesmanship started way beyond the taking of orders, and from that time I have never asked an individual to give me an order for one ton of limestone and, as I see it now, I do not think I shall ask a man to give me an order for some time to come.

Steps in Selling

In analyzing a sale I found it to be composed of a series of steps, the order of which could not be arranged to suit the fancy of some manufacturer desiring to unload surplus production or byproduct. I am listing these steps and shall confine my remarks to each and in their respective order:

Interest; desire; selection; decision; action; service.

A sale must begin with the creation of interest on the part of the prospective customer. He must be told about the product. He must be taught how to use it. He must be shown how it would profit him. He must be shown what he is to expect in return for his dollar. My rambles over Western Ohio showed me that the farmer had practically no interest in limestone, therefore my first problem was to create this interest.

Before attempting work of this kind it was necessary to know what had already

been done along this line in this territory. This required visits among county agents, university extension workers, grangers, visits to banks, and agricultural leaders in various communities.

About the first thing I found was that there was very little real data available on the value of agricultural limestone on Western Ohio soils. Dependable data of this kind require years to secure.

Our first step was to start a limestone demonstration program. Through the cooperation of agricultural leaders in 13 counties in Western Ohio, we were able to put on 70 demonstrations during the summer of 1922.

We got in touch with the Baltimore & Ohio railroad and were able to sell them the limestone religion, and they co-operated with us to the extent of hauling this demonstration car free of freight charges and being represented at various meetings.

Next, the American Seeding Machine Co. was visited. It was also sold on the value of limestone and consented to provide spreaders at all these various demonstrations.

We donated the cars of limestone, varying from 40 to 50 tons each. We found the county agents and agricultural extension workers very responsive to our suggestions and we secured remarkable co-operation from them.

The county agent had direct charge of the entire work. He selected the key men from six or eight different sections of his county and had them agree to haul the limestone from the car to the field and to provide motive power for the spreader. He then gave to this demonstration work one entire week of his time and advertised throughout his county that these demonstrations would be held at certain places and dates. He urged as many as possible to attend, advertising the fact that a soil specialist would be in attendance and give a short address on the value of maintaining soil neutrality.

Newspapers played a mighty important part in our program. From actual records in our offices over 2000 column inches of publicity were given these limestone demonstrations through the newspapers.

A rough sketch of the field was made and an accurate record kept. The farmer was questioned regarding production and soil treatment during the previous five years and our form provided for a report on the limed and unlimed area for five years in the future.

We believe marked success accompanied this work as we had an average of from 35 to 40 farmers attending these meetings.

We have not gone into a county with this work and sold a great tonnage this year—in fact, we were careful not to solicit orders at these demonstrations but to spread all the limestone gospel we possibly could.

It is impossible for me to say at this time whether or not this is to be a really successful work, but I have confidence that we have given birth to interest throughout Western Ohio.

Care and Consistency Needed

I am quite sure this work would be a complete failure if we failed to follow it up carefully and consistently. I am sure that interest has been developed in the minds of a number of farmers, but without the careful coaching and guiding of our continued program I am sure it would die and our time, effort and money spent this year would be a complete loss.

It is our intention to follow up this work year after year for many years and we shall not be disappointed if our sales in Western Ohio do not materially increase during the next one or two years. We consider this a 5- to 10-year program.

In addition to this demonstration work, which is limited to summer months, I attend quite a number of farm bureau, grange, and other farm organization meetings. Last year 61 of these meetings were attended during the time I was on the program.

We had a portable stereopticon outfit with a series of slides and could give an entertainment from 45 min. to 2 hr. in length. This year we have installed a portable moving-picture equipment and I expect to attend at least an equal number of these meetings this year, using the moving picture machine along with the stereopticon.

Value in Attending Organization Meetings

Attending these meetings one has a number of advantages in publicity. If the one attending is able to take advantage of all the opportunities offered, it means a tremendous broadening of personal acquaintance. It means the opportunity of presenting our limestone, although ostensibly I am only talking limestone. It offers the opportunity to place advertising matter directly into the hands of interested parties. It is also an excellent opportunity to select names and addresses for the construction of mailing lists.

A work of this kind gives you close friendship with the county agents and you are often called upon by an agent to provide a program for some farm organization meeting. The friendship and connection with your county agent will develop so far as you are honest and do your work in a trustworthy way. Tell the plain truth and you will find the agent willing and anxious to offer you every assistance.

Through the contact with various county agents, I have been able to arrange for a number of programs for the coming spring. In one county alone the agent has set aside 10 days, has secured the services of soil specialists and we are planning to put on a 5000-acre alfalfa campaign; I will be with this county agent day and night for 10 successive days.

Five thousand acres of alfalfa spells 10,000 tons of limestone and I will be the agent at every meeting. I may not sell the limestone, but I do know that it is going to give me more excellent contact and much broader acquaintance in his county.

It is rather doubtful in my mind at this time whether I shall solicit or consent to take an order in this county, but I most certainly do expect to provide and create the interest and desire so that our salesmen can take the order with ease. I shall expect the salesmen to convince the prospective customer that our material is the only one he should use and I shall feel that my effort as sales manager has sold the limestone, although I am perfectly willing that the salesman should be given the credit and collect his commission for taking the order.

We maintain laboratory equipment for testing for soil acidity. We have, for the last three years, put on soil-testing campaigns in a number of counties and have, in all, tested over 10,000 samples. We also have a portable equipment which can be taken to any organization meeting and tests made in the presence of the farm owners. We keep an accurate record of the tests made and supply copies of them to the county agents and to the state university.

The Psychology of It

There is considerable psychology in this testing. A man may have thought his soil needed limestone, but if this test has been made and his sample shows a lime requirement, that thought has been transferred into a fact and the fact is ever predominate.

In one township in our home county we co-operated with a township farm bureau organization and a complete soil acidity survey was made. Men were employed to visit each farm, make a rough sketch of it and take from 4 to 10 samples from each field, showing on the map the exact location from which each sample was taken. Over 3000 tests were collected in this way.

A township tax map was then enlarged to 10 in. to 1 mile. The Geological Society of Ohio then sketched in colors, various types and phases of soils in this township, after which each individual test was located on this map with a small sticker. Different colored stickers were used to indicate neutral, slight, medium and strong degrees of acidity.

This proved to be a very interesting work and assisted largely in creating interest in this township. We are able to bear out the statement conclusively that the greatest tonnage ever used in this county in one year was less than 100 tons, while this year this township used close to 400 tons.

There are probably many other good

ways of creating interest; probably some of them would be considerably better and more effective than those I have just suggested, but this fact is indisputable: *Interest must be created first.*

Desire

Desire is very closely linked to interest. Interest, we might say, is the infant stage and desire the kindergarten stage.

Our efforts to carry our prospect into the second stage have been along somewhat similar lines to those just mentioned. The same co-operation is secured from agricultural leaders and workers. Tours of inspection are held in the counties where demonstrations have been previously held. The county agent is again called on and he arranges for these tours. It is thoroughly advertised throughout his county and is run on an absolute schedule. They are advertised to start from a certain point, at a certain time, and to arrive at various demonstrations on scheduled time.

We always arrange to have with us one who is well known and well recognized as an authority on agricultural limestone, and at the noon hour we generally arrange to be in some church or schoolyard where a picnic dinner is in order; the speaking is done at this time.

Visits made at the various demonstrations are very interesting; the people are taken out into the field and shown the actual result from a limestone application. Soil-acidity tests are made both on the limed and unlimed areas so that we may determine and exhibit the actual achievement. This is first-hand, unquestionable information. It carries a lot of weight and in a short time everyone in the county knows of this tour even though they may not have been with us.

Using Circular Letters

Another method we use in creating desire for limestone is through circular letters. I do not call these "circular letters," but indirect personal contact.

In these letters we cite the experiences of other people in the same vicinity. We do not tell the Western Ohio farmer what the Pennsylvania farmer says about limestone. We do tell him, however, what his neighbor says. The farmer is not such an uninformed individual that he does not know the existing difference in soil conditions in different states or even different portions of the same state, but when you deliver to him the experience of a man living in his same vicinity, he has confidence. He knows he can see this man and check up our statement with but little inconvenience. Many times in our letters we offer the suggestion that they visit this man and see for themselves what limestone has done.

We consider our newspaper and magazine advertising as affecting desire. We do not carry large enough space to set forth the peculiar advantages of our individual product. Our effort in newspaper and magazine advertising is to put limestone into the minds of as many men as possible. We want them to think about it, worry about it, and finally know about it.

If a man has limestone on his mind he is a much better prospective customer and is much more easily and quickly sold by the salesman than he would be if it were necessary for the salesman to go up against a cold prospect. Our entire effort in the creation of interest and desire is to warm up the prospect before the salesman arrives.

Selection

In selection comes the close co-operation between the salesman and the sales management. It is up to the sales management to be sure the salesman knows all that is to be known about the product he sells. He should know its weak points and be ready to defend them; he should know its strong points and be ready to exploit them. He should be able in a moment's time to show the prospective customer just what he may expect in the way of return on his investment.

Co-operation Most Difficult

The co-operation between the sales management and the salesman is perhaps the most difficult thing we have to run up against in limestone sales. The salesman is working on a commission. The majority of salesmen are either retired or active farmers. Some of them are so enthusiastic about limestone as to make misstatements and ones that are extremely hard to substantiate. We have found a few that were so anxious to make a sale they deliberately misrepresented, and we have found others so "poky" that it is somewhat difficult to keep them active.

We have tried several methods to create the sincere interest in our salesmen, but have not as yet struck on what we might term the really successful contact.

We are trying out this year a big conference to be held in our offices. We expect to have as many of our salesmen present as is possible. We expect to have the best talent available to talk to these men and put them straight on limestone, its value and uses. We expect to take these men through the entire operation of manufacturing limestone and give them as much insight as possible regarding manufacturing methods.

In addition to co-operating with salesmen our circular letter has the tendency in some vicinities to create desire, in others to assist our prospective customers in selection.

If we can show Mr. Farmer in a certain county that several of his neighbors have used our particular limestone with such a degree of success that they are willing to make a public statement that we can broadcast throughout his county, we believe it creates a confidence in the worthiness of our product which will have a great deal of effect in selection.

Decision

Decision is the result of selection and a great many sales managers combine the two into one phase; I do not. There is a great deal of difference between selection and decision. In my own mind I might select a Packard automobile, but more than likely I would buy a Ford.

There is a connecting link between selection and decision, but it is very easily broken. Decision is one element that is difficult to handle from the office. It is at this point the salesman proves most valuable.

Mr. George E. Smith, president of the Royal Typewriter Co. recently said: "The man behind the line does three-fourths of the selling; the man on the line does the rest."

The one-fourth of selling that is to be done by the salesman, or the man on the line, is divided between decision and action. About the only assistance the sales manager can offer his salesman in assisting decision on the part of the prospective customer is:

Stand back of every statement made by your salesman, support and protect him, let your prospective customer understand the salesman has the unwavering support and backing of the manufacturer. So conduct every element of your contact with customers that they may have absolute confidence in the salesman. This will relieve the mind of the prospective customer in knowing that he is doing business with a man whose every statement is good and will be protected. This will have a great deal to do with decision.

Action

Action is another element of salesmanship. It should be comparatively easy if the previous steps have been taken in the proper manner. If the prospective customer has been guided through the first four steps in a sincere, honest and confidence-inspiring way, he is very likely to be waiting for the salesman and ready to sign the dotted line. However, it sometimes becomes necessary for the salesman to exert his personality at this time.

This is particularly true at the present time when agriculture is in a seriously depressed condition. Under present conditions the farmer has a tendency to hold on to the hard cash, fearing what the future may have in store for him. It then becomes necessary for the salesman, properly backed and supported by advertising, to convince Mr. Farmer that the dollar spent will bring back two.

The efforts of our office along this line of action are limited to selling letters which are sent out to our mailing list at the

time of the year when the farmer should be in a buying mood.

It is not at all difficult to inspire our salesmen to action. Action is the natural element of a salesman. Their second nature is to get the signature on the dotted line. Our duty is to provide as many of the first three or four stages of a sale as is possible in an effort to make it as easy as possible for our salesmen to "close up." It is an easy matter for any of us to see how much more prosperous a salesman can be if the prospective customer is in a recipient mood when visited by the salesman.

Our instructions to our salesmen are: Do not waste time on a cold proposition. It is not your fault if you do not sell him limestone. It is ours. Send us his name and address and let us put him through the first three or four stages.

What Service Is

Service is 50 per cent of a sale. The exchange of merchandise for cash is the other half. The sale you have made and do not follow up with efficient service is only half made. Service is the most abused word in the business dictionary. Some people interpret service as meaning "the painful extraction of cash from a previous customer when he is not in a position to defend himself." In a great many instances, service of the above interpretation loses much business and the firm would be better off to eliminate entirely "service" from its vocabulary.

The interpretation we put on service and try to follow out is: "A sincere interest in the effectiveness and value of our merchandise to our customer."

We follow up every shipment of limestone that leaves our plant. We want to know whether or not it was delayed in transit; whether it suffered abuse while in transit; and whether the railroad company overcharged in the collection of freight.

The letter we use in this service follow-up is such that it makes every customer a member of our board of control. We ask for suggestions and criticisms, and we want to tell you right here that these suggestions and criticisms received are given sincere attention.

We have been able to produce a better product because of some of these suggestions. We have been able to improve freight transportation by these suggestions—in fact, we have received suggestions from our customers that have affected every department of our business.

I have driven 50, 75 or 100 miles to visit a customer who was disappointed in the return from his limestone. In a majority of instances, I found limestone put on a neutral soil. This is a most difficult situation to face. Our salesman had undoubtedly represented to this man that certain things could be expected, although he did not know soil conditions in the field on which this limestone was to be applied. However, I have always been able to leave the customer in a friendly spirit and to eliminate the recurrence of this sort of thing.

We urge our salesmen to secure samples of soil from the fields on which the limestone is to be applied, mail them into our office, where we run analyses and make recommendations for application. We have absolutely cancelled some orders because of this work, the analysis showing that limestone was not needed.

This sort of service not only affects the sale after shipment is made, but it also plays an important part before the order is signed. We make just as intensive a drive to avoid the use of limestone where it is not needed as we do to encourage its use where it is needed.

Crushed Stone Railway Ballast

By Theo. Bloecher, Jr.

Division Engineer, Baltimore & Ohio R. R., Baltimore, Md.

Representing the Ballast Committee of the American Railway Engineering Association

THE subject covered by this paper is but one phase of the activity of your association's membership, although an important one. Ballast is a fundamental necessity for the transportation facilities of the world and of the various kinds in use, crushed stone is, up to the present, the ultimate development.

Much study has been given the subject by the railroads and the fact that some questions remain unsettled is evidence of the need of co-operation between the producers and the users of crushed stone ballast. An ambitious program is drawing to a close and the thought presents itself that the spirit animating the arrangements will, without a doubt, have beneficial results.

First Important Use of Crushed Stone

In the early days of railroading, curious ideas regarding foundation for the track were prevalent. The original construction of the old Erie Railway was planned on pile trestles, but soon abandoned. Later construction on other lines showed the influence of traditional practices in foundation work, and we see large cut stone slabs to support sleepers under the track. Gradually it became apparent that a rigid cushion to distribute the load over the subgrade, and at the same time one elastic enough to permit a relatively fine adjustment of the track to line and surface, had to be sought in a porous material. As experience accumulated, crushed stone naturally developed and such ballast was for a long time the most important use to which this product was put, excepting, perhaps, its use on highways as initiated by the Scotch engineer MacAdam.

Your industry entered a new era with the development of concrete as a material of construction and this has resulted in an increased demand and expansion which must increasingly affect the use of crushed stone as ballast by railroads, on which there will be a few remarks further on.

Requirements of Ballast Stone

The requirements for good ballast stone are relatively few. It must be hard to resist tools used in track work. It must break into jagged pieces of suitable shape which will firmly interlock. It must be dense with a minimum of absorption of water and it must weather well and keep its jagged shape. It must, in addition, be produced in sizes of the maximum uniformity in order to secure the maximum percentage of voids. A crushed stone satisfying the above conditions to the greatest extent is one most suit-

able as ballast. Such a stone will quickly pass off water, the arch enemy of the railroads, and will provide a firm foundation for the heavy loads which must be distributed over the roadway.

The American Railway Engineering Association has only recently propounded a specification as a guide to the users of rock ballast. This specification has not been applied a sufficiently long time to justify drawing of conclusions based on experience. It is earnestly recommended that the National Crushed Stone Association study these specifications and develop facilities for carrying on the tests therein outlined. This specification is published in the "Proceedings" of 1920, Vol. 21, pages 439-442 (reprinted in Rock Products, March 27, 1920, and with revisions in March 26, 1921), and was formulated after a study of the literature on the subject. This specification embodies the experience of representative railroad engineers. The work of the U. S. Government is of particular interest and its publication, No. 370, Department of Agriculture, is called to attention.

The crushing operations and the screening of the stone and the efficiency and economy with which this work is done is of the utmost importance to the trade and a prominent place in these discussions has been assigned to these phases of your work. It would be presumptuous to touch on this subject in view of the attention it is receiving, but the results of your endeavors will be reviewed with interest by railroad engineers. The handling of the quarry product and its distribution and application to the roadbed is, however, the particular problem of the railroads. Herein much has been done and a heavy investment in equipment has been made to place the ballast where it belongs and to do it economically and efficiently.

Uniform Size Essential

The subject of proper size of crushed stone ballast is an open one, and one on which a wide difference of opinion exists. All ballast, to be effective, must drain properly and this means it must be clean and the voids open. When ballast becomes foul it must either be removed or it must be cleaned. Rock ballast can be cleaned, if of sufficiently large size, and methods have been developed and are being perfected to do this at a cost representing a substantial saving over renewal. There is, however, a drawback to a large size of ballast stone, and that is the difficulty of fine surface adjustments under traffic without breaking up the stone in the act of tamping. It stands to reason that to raise a low spot in the track, say one-half an inch, with stone of so-called "3-in." size, presents a problem to the trackman which he solves by breaking up the stone to proper size to attain the result desired. It seems anomalous to expend effort and money to screen out small sizes and then break up the large sizes while working track.

On the other hand, to use stone of varying sizes tends to fill the voids and reduces the value of the product as ballast. Herein the requirements for ballast and for concrete stone are radically different. A minimum of voids in concrete aggregate is desired and the opposite is true of rock for ballast purposes. Again, concrete calls for large and small aggregate, the former for monolithic and the latter for reinforced work so that it seems construction work requirements call upon the quarries for a fuller utilization of their output of crushed stone than do the railroads for ballast use. The result of this conflict of interest has no doubt been of influence on the cost of ballast. It may, therefore, be suggested that this matter be studied with a view to producing, economically, that product required by the railroads and at the same time serving the other market satisfactorily. Both markets are destined to grow, although, perhaps, at different rates, but the necessity for stone for ballast is of growing importance on account of the great increase in train and engine weights coupled with high speeds, making a firm foundation essential.

Opportunity for Co-operation with Producers

A small size for ballast stone has the effect of reducing the cost of maintaining the surface of track and at the same time gives as good a foundation as the larger size. The small stone, however, beyond a certain limit, cannot be cleaned by screening, and when too foul, must be wasted. It seems probable that the small stone fouls more slowly than the large and under certain conditions, therefore, the ultimate cost may be about the same for either size. The cost of production will be an important factor and it is here that co-operation may result in benefit to all. It is undeniably a fact that a large railroad mileage now without stone would be rock ballasted but for the cost, and certain locations could profitably be studied by your membership to develop suitable material for ballast and prepare the way for the other uses of crushed stone which are sure to grow.

B. D. Pierce, Jr.

As to the various kinds of stone to be used for rock ballast, it can, in general, be said that rock suitable for railroad track will be suitable as well for concrete. Our old friend trap rock is not available at many places and, while a prime favorite, is only one of many giving good results; and requirements will often have to be scaled down to utilize, economically, the material nature has provided in a given region. The limit to which such a modification can go depends on too many factors to be gone into here, but will have to be based on an analysis of particular cases.

In concluding, let it be said that the aims of the National Crushed Stone Association cannot fail to strengthen an industry national in scope and the results of the deliberations to be concluded today will be reviewed and valued by others as well as your membership. A full measure of success will no doubt be attained and is certainly due your efforts.

Membership Campaign

By B. D. Pierce, Jr.

I HAVE nothing to say except that I am a member of that committee, the same as every other man here. We have got to go out and do the job; if we sell ourselves, we can sell others. There is no question about what the association can give, still many have been asked what it can give. In the first place, I think that through an organization of this kind we can seek to get legislation, with the help of other organizations, the same as we are going after this immigration now. We have already wired Washington to get in touch with the people that we think are the ones for us to reach, and as regards the railroad situation, the matter of cars, why I think we can do something along that line, and I think a lot of the small producers would appreciate being members of this organization, if it is only a small membership fee of $25. Those of you who can take a $100 membership ought to do it.

I know I have had a splendid time here and I never saw this thing working as it is now. I am sure if you all put your shoulders to the wheel, and feel as I do, you will consider it a privilege to be a member. If you feel as I do, this is going to be a good organization and we will have at least 500 members inside of a year. That is what we should have.

Blast-Furnace Stone and Open-Hearth Furnace Flux

By J. H. Campbell
Robert W. Hunt Co., Chicago, Ill.

THE industry to which you furnish stone as a fluxing agent originated almost with the human race. In Genesis you will find a statement that Tubal Cain in the sixth generation from Adam was a hammerer and artificer of iron and brass. In the British Museum is a wedge taken from one of the air chambers in the Gizeh Pyramid dating to 3733 B. C. This piece of iron from its wedged shape would suggest to you quarrymen the old wedges formerly used to take out dimension stone and may have been used in the building of the pyramid.

In the early days of the iron industry, high furnaces were not used and very small amounts of iron were made in the blast-furnace operation, which at that time, really produced wrought iron or steel rather than cast iron, a portion of the iron ore being used as flux.

It may interest you to know that this process of producing iron from iron ores has been found in use in India, Madagascar, Syria, the head waters of the Nile, Styria, Germany, Sweden, England, Scotland and Catalonia in Spain, and was the process used by the early colonists in our own country.

In the year of 1619, Dud Dudley devised the process for using coal instead of charcoal in the production of iron. The furnace that he used was higher undoubtedly than those preceding it and thus permitted iron to take up sufficient carbon to render it fluid and produce the first cast iron in a high blast furnace.

The use of limestone as a flux probably had its origin about this time, however, metallurgical history does not give us a definite date; probably because many ores were self-fluxing or needed a flux other than limestone, and the use of limestone gradually came into the industry as have many other of the improvements, the exact date of whose adoption is indefinite.

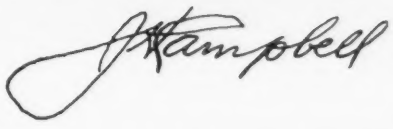
Value of Various Limestones as Flux

Your interest in limestone naturally centers on its use as a flux and methods of valuating. Limestone is used in the blast furnace primarily to render fusible the slag or sand and aluminum oxide or slatey materials and clayey materials of the ore, and when magnesia is present in the stone, the resulting slag is more fusible. In order to determine whether one stone is better as a fluxing agent than another, a chemical analysis of the stone is made. Suppose that this chemical analysis shows as follows:

	Per cent
Silica	1.44
Aluminum oxide	2.12
Calcium carbonate	82.55
Magnesium carbonate	13.50

Calcium carbonate contains 56 per cent of calcium oxide and 56 per cent multiplied by 82.55 per cent gives 46.23 per cent total base in calcium carbonate.

Magnesium carbonate contains 47.60 per cent magnesium oxide and 13.50 per cent of magnesium carbonate in the stone multiplied by 47.60 per cent, or the percentage of magnesium oxide in the carbonate, gives you 6.43 per cent total base in the magnesium carbonate. The sum of these two, 52.66 per cent, is the total base in the stone.



Adding together the silica and the aluminum oxide, or 1.44 per cent plus 2.12 per cent, gives 3.56 per cent total acid.

Subtracting from the total magnesia and lime gives 49.10 per cent of available base in the stone. The higher this available base in a limestone, the more valuable the stone is as a fluxing agent.

Effect of Magnesium

Magnesium oxide is present in practically all limestones. It was debatable for quite a period in furnace operation as to its value as a flux, and I can well remember statements made in former years that dolomitic limestone should not be used anywhere as a fluxing agent in a blast furnace.

However, it undoubtedly has some value, especially in giving a multiplicity of bases in the slag and thus making their formation and fusion temperature lower than it would be with lime alone. Unquestionably, with higher sulphur in cres and fuel, this might be a disadvantage, as it could prevent the temperature of the furnace going sufficiently high for sulphur to combine with lime.

Stone going into the blast furnace is usually specified as passing a 4½-in. ring and retained on ½-in. ring. It is desirable that the stone be free from dust, and not have such fineness as would road metals or materials for concrete aggregate, as these fine materials would have a tendency to plug the furnace and prevent the ascending gases and air from having a free flow and thus causing the pressure to go up in the furnace.

The size of the stone used will have to depend, of course, to some extent, on the judgment and experience of the blast furnace men. Some stones do not decompose in the furnace as rapidly as others and if used in large pieces might reach to the tuyere level undecomposed, thus tending to throw the furnace off of regular running. Where stones are hard to decompose or refractory, smaller crushing would be permissible than in a more easily decomposed stone.

Besides the fluxing action, limestone also has another function in the blast furnace, and that is to give a sufficient volume of slag to make the furnace run or drive readily, producing thus a larger output and more uniform running, and the slag volume thus produced floating on top of the fluid iron in the hearth protects the iron from oxidation and wasting.

In the open-hearth furnaces, in the production of steel, the addition of lime as limestone is primarily to combine with the slag produced from the oxidation of the silicon in the pig iron, to hold the phosphorus in the slag and to hold the sulphur in the slag, which slag protects the metal from direct contact with the flame and heated air passing through the furnace.

A secondary function is to help the boil and thus insure a lively reaction and a proper mingling of the various materials in the hearth. The lime probably also acts as a partial oxidizing agent due to the breaking up of some of the carbon dioxide of limestone by the carbon and silicon from the pig iron in the hearth.

It is essential that the charge be kept distinctly basic with the lime in order to prevent phosphorus from again uniting with the iron.

The limestone charge in open-hearth furnace will probably amount to about 5 or 6 per cent of the total charge. The valuation of the limestone for use in open-hearth furnace would be exactly the same as for the blast furnace.

Fire Resistance of Concrete Protected and Reinforced Concrete Building Columns*

By S. H. Ingberg
Physicist, U. S. Bureau of Standards, Washington, D. C.

DURING the past five years two series of fire tests of columns have been completed, the data from which have materially increased our knowledge of the safety of these building supports when exposed to fire. One series, including tests of protected and unprotected structural steel, cast iron, concrete-filled pipe, and timber columns, and reinforced concrete columns with integral concrete protection, was a co-operative investigation by the Associated Factory Mutual Laboratories of Boston, Mass., the Underwriters Laboratories, Chicago, Ill., where the tests were conducted, and the Bureau of Standards. The other series, consisting of fire tests of concrete columns, was conducted by the Bureau of Standards at its former Pittsburgh testing station.

I. Jointly Conducted Fire Tests

1. Scope and Methods

This series comprised 106 tests of columns of which 91 were fire tests and 15 fire and water tests. In the fire tests the columns were subjected to an average working load computed by accepted design formulas, and exposed to fire in a gas-fired furnace (Fig. 1), the intensity of the exposure being regulated to conform with a predetermined time-temperature relation. In the tests, after a rapid rise in the first 5 or 10 min., a furnace temperature of about 1700 deg. F. was attained at the end of 1 hr., 2000 deg. F. at 4 hr., and 2300 deg. at 8 hr., for the tests continued to this rather extreme point. The efficiency of the column or its protecting material was judged by the length of time it withstood the combined load and fire exposure. In the fire and water tests the column was loaded and exposed to fire for one-half to one hour, when the furnace doors were opened and a hose stream applied to the heated column.

2. Material and Workmanship

A determined effort was made to obtain for these tests, columns representative in material and workmanship of the field constructions. Fig. 2 shows methods employed in placing the concrete protected and reinforced concrete columns. As an aid in obtaining representative workmanship, several experienced men connected with local construction companies were at different times placed in charge of the mixing and placing. These men were allowed to determine consistency of mix and the method of mixing and placing, except that time of mixing was required to be between 1 min. and 1½ min. Test cylinders were taken from nearly every batch and general results of compression tests of these cylinders are shown in Fig. 3, the most marked characteristic being a wide range in strength, due mainly to difference in water content of the concrete mixtures made at different times, and is probably comparable with what obtains in a similar range of field placed concrete, although as properly placed in large building members

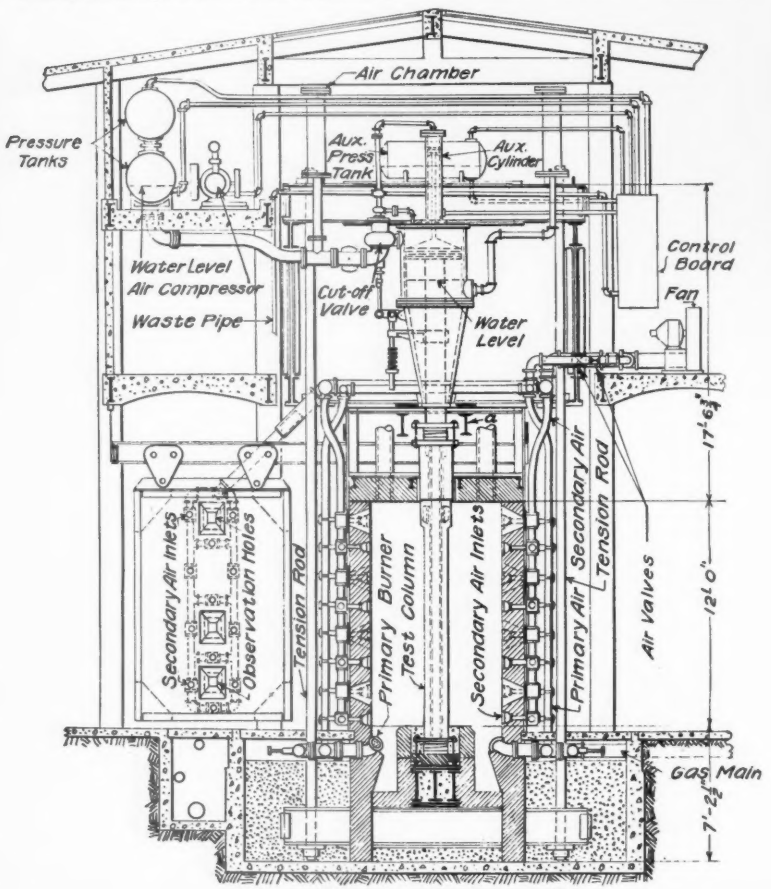


Fig. 1—Elevation of testing machine

S. H. Ingberg

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the general strength of the member will be more nearly the average obtained with the test cylinders. This large variation in compressive strength appears to have had no marked influence on the fire-resistance of the concrete.

3. Results of Fire Tests

The results of fire tests of unprotected columns and columns employing portland cement concrete as a covering or column material are outlined in Tables 42a, 42b, 42d, and 42h.* The column length exposed to fire was 12 ft. in all cases, an upper enlarged extension of 3 ft. above the roof of the furnace serving as a means for transferring the load to the portion exposed to the test fire. Test durations by groups are given in Figs. 4 and 5.

As seen from the tables and diagrams, unprotected and unfilled structural steel columns withstood the fire test under load from 11 to 21½ min.; with interior or re-entrant spaces filled with concrete but with exposed metal flanges the resistance was increased by an average of three times that in the unprotected condition, and the latticed columns, Nos. 18 and 22, protected by concrete to the outside of the rivet heads, withstood the tests for 2 hr., 53 min. and 5 hr. 14 min. Views of unprotected and partly protected columns after test are shown in Figs. 6 and 7.

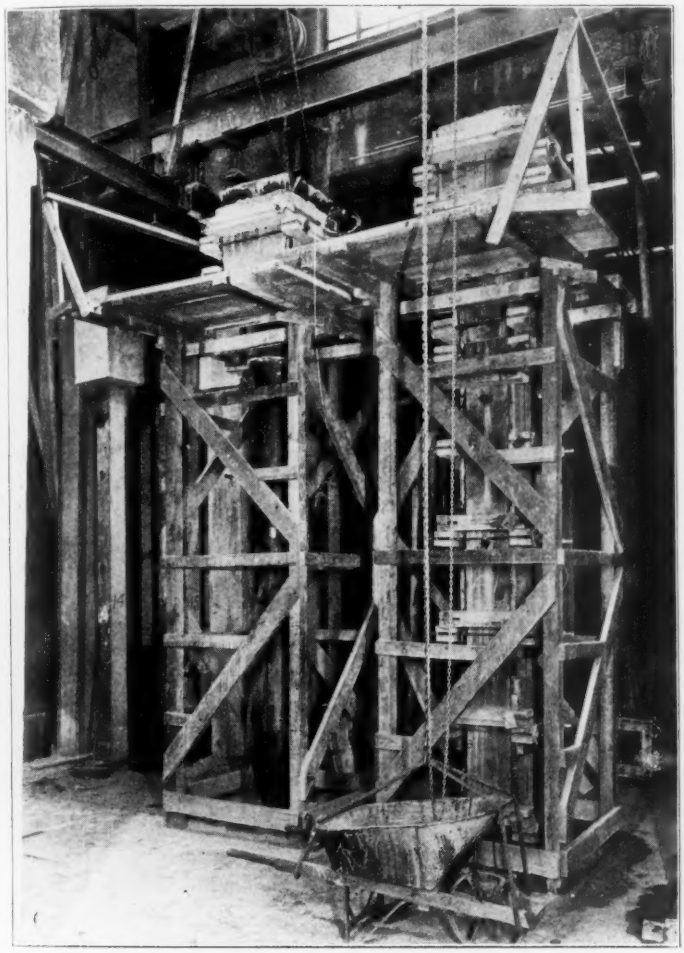


Fig. 2—Forms and staging for placing concrete

In Table 42d are given the results of tests with 2-in. and 4-in. round and square concrete protections. Here a wide range in effectiveness developed, attributable to difference in mineral composition of the concrete aggregates used, the strength of the concrete as exposed to fire, and the size of the covered column, the resistance increasing appreciably with size. The largest source of variation in fire resistance of concrete is mineral composition, particularly of the coarse aggregate. In the tests with 2-in. concrete protection the test durations ranged from 1 hr. 47 min. where silicious gravel was used to 6 hr., 34 min. and over for crushed limestone and calcareous gravel, with intermediate degrees of resistance developed by concrete coverings made with trap rock, sandstone, and cinder. Similarly, with 4-in. protections, test durations of 3 hr. 41 min. obtain with silicious gravel concrete, 7 hr. 23 min. to 7 hr. 58 min. with trap rock and granite as coarse aggregate, and test periods of over 8 hr. with limestone aggregate. Columns with 4-in. coverings of limestone concrete did not fail under working load in the 8-hr. fire test, and sustained while hot, loads over three times the working load. Views of typical concrete protected columns after test are shown in Fig. 8.

The cause of the cracking incident with fire exposure of concrete made with silicious aggregates can be ascribed to the strains set up in minerals like chert and quartz when heated. Chert has a variable amount of combined water that disrupts it when liberated by heat and it also has points of abrupt volume change as low as 210 deg. C. (410 deg. F.). Quartz has a decided point of abrupt volume change at its transformation point, 573 deg. C. (1063 deg. F.). Sandstone is made up mainly of cemented grains of silica, and on exposure to fire concrete made with it, develops effects similar to those with silicious gravel concrete, although to somewhat smaller extent. Granite contains quartz, feldspar, and ferro-magnesian minerals in varying amounts, the cracking of concrete made with it when exposed to fire being less marked than for aggregates having a higher silica content. The quartz con-

TABLE 42a. RESULTS OF FIRE TESTS—UNPROTECTED COLUMNS

Test No.	Section	Nominal area, sq. in.	l/r	Load sustained during test: Total load, lb.	Unit load, lb. per sq. in.	Time to failure, hr.—min.	Furnace exposure, per cent
1	Rolled H	10.17	75.6	119,500	11,750	0—11¼	95.6
2	Plate and angle	13.00	111.8	116,000	8,900	0—19¼	97.0
3	Plate and channel	8.76	64.7	111,000	12,650	0—14	101.4
4	Latticed channel	7.78	44.0	111,000	14,250	0—11	101.1
5	Z-bar and plate	9.32	81.7	105,000	11,250	0—14¼	100.0
6	I-beam and channel	10.12	72.1	122,000	12,050	0—17	89.6
7	Latticed angle	8.44	40.7	122,500	14,500	0—14	96.3
8	Starred angle	13.27	108.5	124,000	9,350	0—21½	99.0
9	Round cast iron	14.73	68.2	95,500	6,500	0—34¼	101.2
10	Round cast iron	14.73	68.2	95,500	6,500	0—34½	101.7
10A	Round cast iron	14.45	63.2	98,500	6,800	0—34¼	100.3
11	Round cast iron (concrete filled)	14.73	68.2	95,500	.....	0—45¼	103.1
12	Steel pipe (concrete filled)	Steel 6.93 Concrete 38.74	63.9	114,500	.....	0—36	101.9
13	Reinforced steel pipe (starred angles imbedded in concrete filling)	Steel 18.36 Concrete 40.07	68.2	236,000	.....	1—11¾	99.3

*The tables refer to numbers in the complete report of the investigation entitled "Fire Tests of Building Columns," the joint edition (389 pp.) being published by Underwriters' Laboratories and the government edition (375 pp.) as Paper No. 184 in the Bureau of Standards' technologic series.

tent of true trap rock is very small and the fire effects on concrete made with it can be attributed to normal expansion and shrinkage. At the higher temperatures attained in fire tests and building fires some fusion of trap rock concrete as well as granite and cinder concrete will occur, although from the indications in the tests such effects will seldom seriously reduce the resistance of concrete protected or reinforced concrete columns.

Results of tests of reinforced concrete columns are given in Table 42h. The aggregates employed were limestone and trap rock, the limestone concrete columns all withstanding the 8-hour fire test under working load and supporting while hot loads averaging more than twice the working load before failure. Two of the trap rock concrete columns failed under working load during the eighth-test hour, the other sustaining the load until the end of the 8-hour period, and 25 per cent additional load before failure resulted. Views of reinforced concrete columns before and after test are given in Fig. 9.

A nominal thickness of concrete of 2 in. all around was considered as protection, and deducted in computing the working loads to be applied. The last column in all tables gives the approximate relative intensity of the fire exposure as indicated by the temperature readings, considering the average exposure for all tests to be 100. Since the maximum equivalent intensity and duration of a fire in a building seldom if ever exceeds that corresponding to a 4-hour test fire, it is seen that the fire resistance afforded by the reinforced concrete columns tested is ample to provide for all exigencies met with in building occupancies. With limestone and trap rock concrete 1½-in. protection outside of the reinforcement would apparently be sufficient for general

TABLE 42b. RESULTS OF FIRE TESTS—COLUMNS PARTLY PROTECTED BY CONCRETE

Test No.	Section	*Protection— Mixture	Kind of concrete	Age of covering, days	Load sustained during test, lb.	Time to failure, hr.—min.	Furnace exposure, per cent
14	Rolled H	1:2:4	Joliet gravel	405	119,500	1—04¼	85.1
15	Rolled H	1:2:4	Rockport granite	407	119,500	0—48¼	91.5
16	Plate and angle	1:2:4	New York trap	416	116,000	0—44½	94.8
17	Plate and angle	1:1½:4½	Hard coal cinders	408	116,000	0—41¾	99.6
18	Latticed channel	1:2:4	New York trap	418	111,000	2—53	98.1
19	Z-bar and plate	1:3:5	Chicago limestone	414	105,000	1—07¼	95.8
20	I-beam and channel	1:3:5	New York trap	415	122,000	1—24½	100.2
21	I-beam and channel	1:3:5	New York trap	416	122,000	1—21¾	99.6
22	Latticed angle	1:2:4	Chicago limestone	408	119,500	5—14	99.2

*Re-entrant portions and interior filled with concrete.

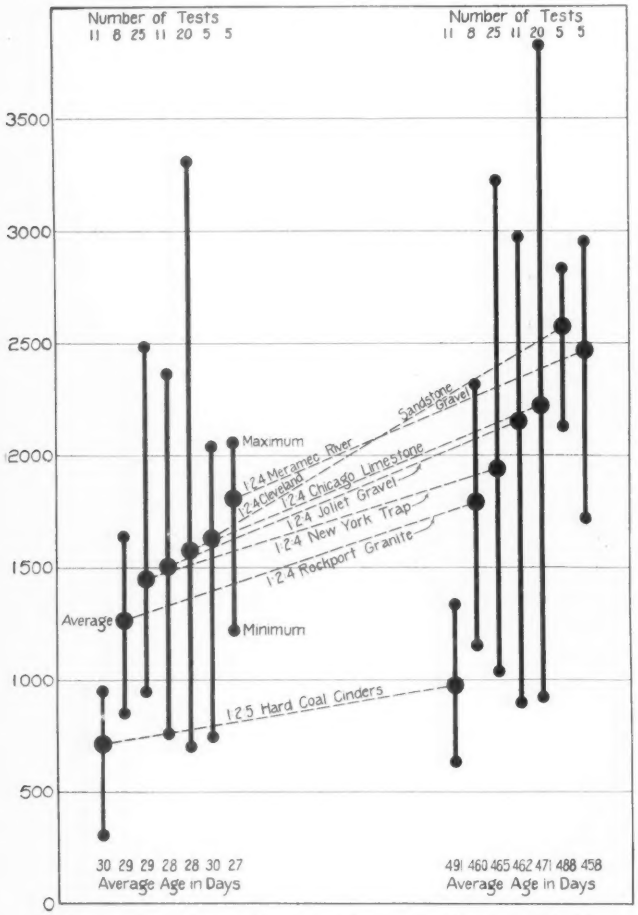


Fig. 3—Average and range of compressive strength of 1:2:4 and 1:2:5 concrete

Limestone concrete, in addition to being nearly free from disruptive fire effects, affords an added degree of insulation due to heat absorbed by the calcination of the limestone, and the protection afforded by the

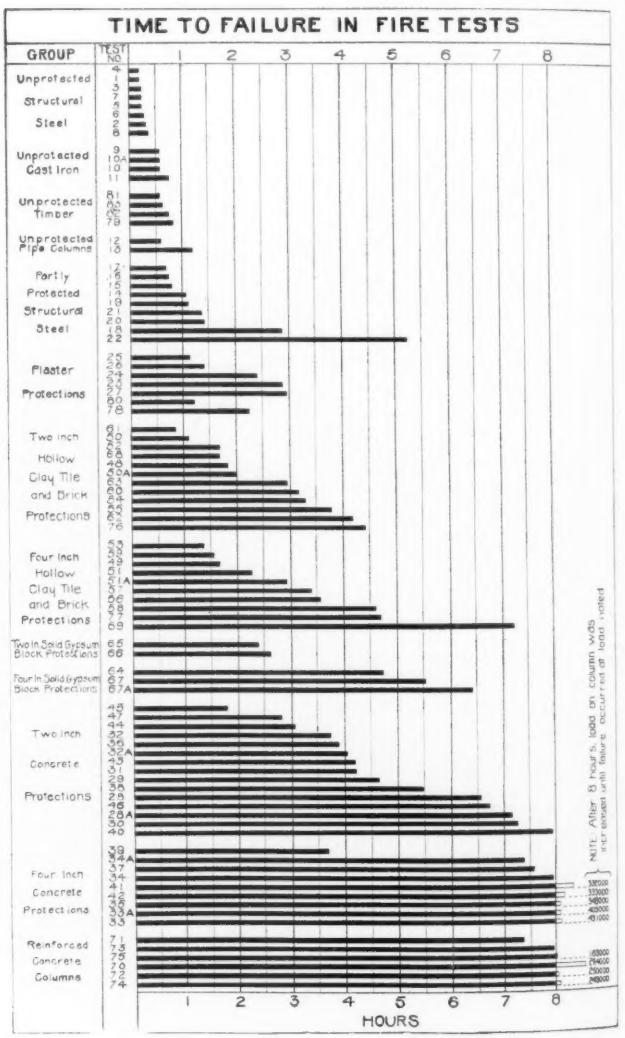

TIME TO FAILURE IN FIRE TESTS
GROUP
TEST NO.
1 2 3 4 5 6 7 8
Unprotected Structural Steel
Unprotected Cast Iron
Unprotected Timber
Unprotected Pipe Columns
Partly Protected Structural Steel
Plaster Protections
Two Inch Hollow Clay Tile and Brick Protections
Four Inch Hollow Clay Tile and Brick Protections
Two in Solid Gypsum Block Protections
Four in Solid Gypsum Block Protections
Two Inch Concrete Protections
Four Inch Concrete Protections
Reinforced Concrete Columns
HOURS
NOTE: After 8 hours, load on column was increased until failure occurred or load noted

Fig. 4—Time to failure of columns in fire-test series

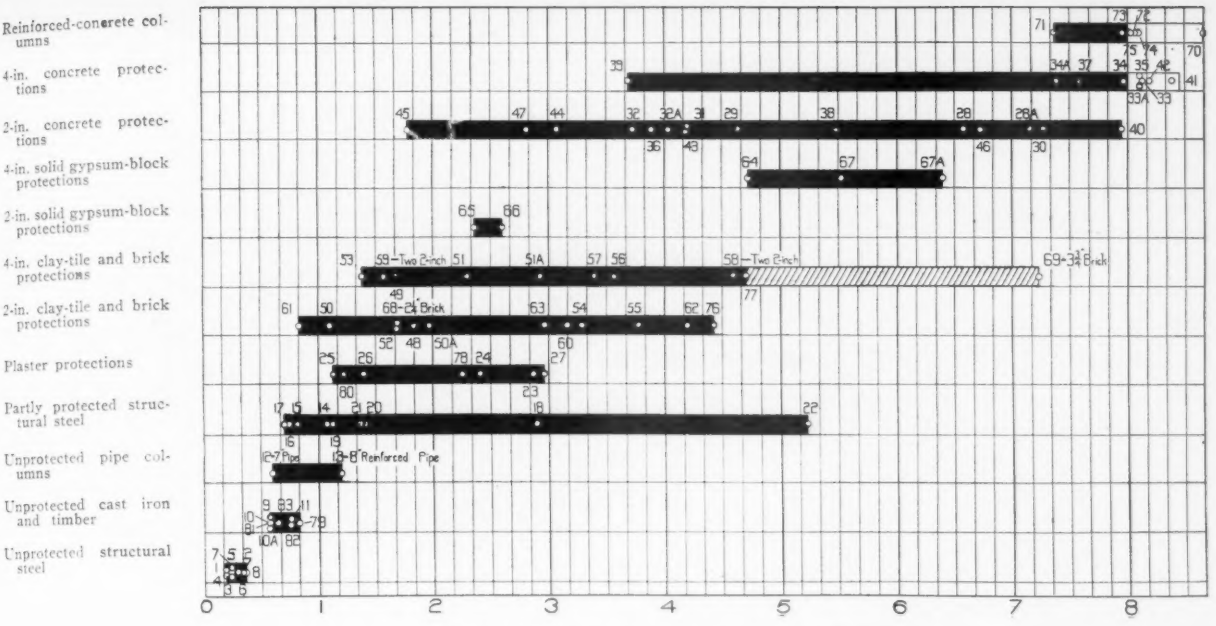


Fig. 5—Results of fire tests compared by groups

building purposes.

The results should not be taken as applying broadly to this type of column, as the aggregates used were those that would be expected to give the best results. When these tests were planned, little was known relative to the effect of mineral composition of the aggregate on the fire resistance of the concrete; otherwise tests of reinforced columns that would have developed more nearly the range of results to be expected of concrete in use would have been introduced.

4. Results of Fire and Water Tests

During the water application portions of the covering were carried away that were damaged during the fire exposure, the criterion being the ability of the column to withstand a fire recurring after a moderate water application estimated as equivalent of a two-minute hose stream application. The results of the tests indicated that properly tied concrete protections will not fall off to such extent as to make the column subject to early collapse in a recurring fire, although where silicious aggregate was used portions of the steel flanges generally became exposed. The intensity and duration of such fire can justly be taken as considerably moderated by the previous fire and water exposure. The same conclusions as to sufficiency under fire and water exposure held relative to reinforced-concrete columns made with limestone and trap rock aggregate. In the middle section of the columns subjected to fire and water a concrete made with silicious aggregate was used. Here most of the protection outside of the steel fell off after a brief water application and the safety of the column on being again exposed to fire of moderate duration is less assured than with concrete made with non-silicious aggregate. Views of concrete protected and reinforced-concrete columns, before and after fire and water tests, are shown in Figs. 10 and 11.

2. Fire Tests of Reinforced-Concrete Columns by Bureau of Standards

1. Scope of Tests

Considering the need for information on the effect of fire on reinforced-concrete columns following several fires in concrete buildings in which column failure was involved, an investigation was undertaken that covered the main types of concrete columns in use as made with different aggregates. The investigation was extended to determine the effectiveness of a number of methods of protecting columns that otherwise did not develop an adequate resistance for all purposes as tested unprotected.

In the entire investigation 90-column tests were made, of which 62 were fire tests, 16 were compression tests of columns, which had not been subjected to fire test, and 12 were compression tests of columns which had been fire tested, but which, after four hours of fire test, did not fail while hot un-

TABLE 42d. RESULTS OF FIRE TESTS—COLUMNS PROTECTED BY CONCRETE

Test No.	Section	Protection: Thickness, in.	Protection: Mixture	Protection: Kind of concrete	Age of covering, days	Load sustained during test, lb.	Time to failure, hr.—min.	Furnace exposure, per cent
28	Rolled H	2	1:2:4	Chicago limestone	437	119,500	6—33¾	96.9
28A	Rolled H	2	1:2:4	Chicago limestone	438	119,500	7—09¼	95.2
29	Rolled H	2	1:2:4	New York trap	435	119,500	4—38½	99.5
30	Rolled H	2	1:2:4	Joliet gravel	439	119,500	7—16	99.2
31	Rolled H	2	1:2:4	Cleveland sandstone	500	119,500	4—11½	99.4
32	Rolled H	2	1:2:5	Hard coal cinders	503	119,500	3—44	101.3
32A	Z-bar and plate	2	1:2:5	Hard coal cinders	497	105,000	4—02	100.5
33	Rolled H	4	1:2:4	Chicago limestone	450	119,500 ‡431,000	8—08	99.2
33A	Rolled H	4	1:2:4	Chicago limestone	455	119,500 ‡405,000	8—07¼	98.8
34	Rolled H	4	1:2:4	Rockport granite	452	119,500	7—58	98.6
34A	Rolled H	4	1:2:4	Rockport granite	454	119,500	7—23	102.5
35	Rolled H	4	1:3:5	Chicago limestone	504	119,500 ‡348,000	8—07	101.3
36	Plate and angle	2	1:2:4	New York trap	445	116,000	3—53¼	100.3
37	Plate and angle	4	1:2:4	New York trap	503	116,000	7—34½	99.9
38	Plate and channel	2 round	1:2:4	Joliet gravel	449	*116,500	5—28¾	100.2
39	Plate and channel	4	1:2:4	Meramec R. gravel	436	*116,500	3—41¼	98.3
40	Latticed channel	2	1:2:4	New York trap	501	111,000	7—57	99.1
41	Z-bar and plate	4 round	1:3:5	Chicago limestone	451	105,000 ‡332,000	8—24½	99.6
42	Z-bar and plate	4	1:3:5	Chicago limestone	453	105,000 ‡333,000	8—11½	98.5
43	I-beam and channel	2	1:2:4	Cleveland sandstone	456	122,000	4—11	98.7
44	I-beam and channel	2	1:3:5	Cleveland sandstone	458	122,000	3—04¼	100.6
45	Starred angle	2 round	1:2:4	Meramec R. gravel	447	124,000	1—47	99.7
46	Latticed angle	†2	1:2:4	New York trap	451	122,500	6—43½	99.0
47	Round cast iron	2	1:2:5	Hard coal cinders	446	95,500	2—48¾	99.6

*Heavier load used as plates have 1/32 in. greater thickness than nominal.
†2-in. outside rivets, 3½-in. outside angles.
‡Load necessary to cause failure of column. After 8 hr. the load was increased until failure occurred.

der the maximum load obtainable with the equipment. The fire exposure under working load was generally continued to four hours, unless failure occurred before this point was reached. At the end of the four-hour period the column was loaded to failure or up to the limit of the equipment (about 600,000 lb.). The full report of the investigation has not as yet been published, but progress reports are given in the proceedings of the American Concrete Institute for 1918, 1919, and 1920.*

The series included tests of plain concrete columns, columns reinforced with longitudinal bars, and columns with combined reinforcement of spiral hooping and longitudinal bars. The columns were generally round of 18-in. outside diameter with 1½-in. of protective concrete outside of the reinforcement. Comparable tests were made of some square columns, as also of 12-in. round columns. The concrete aggregates used included limestone, trap rock, calcareous gravel, blast furnace slag, two silicious

Fig. 6—Unprotected structural steel columns, tests Nos. 6 to 8, after fire test

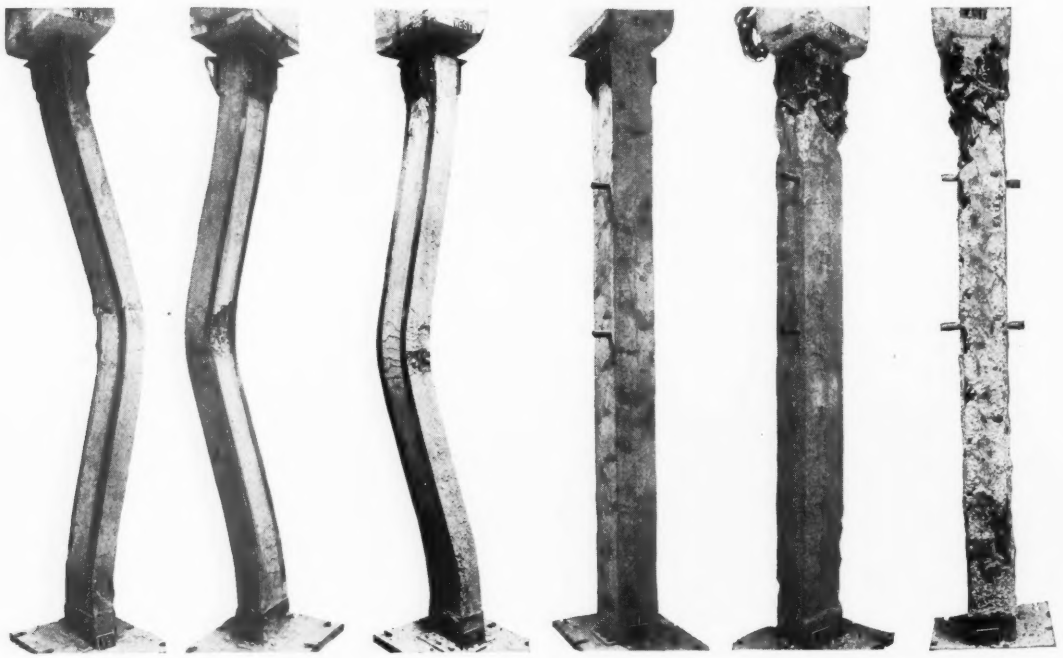


Fig. 7—Partly protected structural steel columns, tests Nos. 19 to 22, after fire test

*W. A. Hull "Fire Tests of Concrete Columns."

gravels, and one pure quartz gravel.

Tests were made to determine the effect on fire resistance of increasing the thickness of concrete protection outside of reinforcement and of embedding metal mesh in the protection. Experiments were also made with protections of cinder concrete and molded gypsum and also with various plaster protections. Load tests were made of unexposed columns comparable with those subjected to fire tests.

2. Summary of Results—(a) Concrete of Silicious Aggregate

Of the three silicious aggregates, one contained a large proportion of sandstone pebbles and a smaller amount of quartz pebbles. This aggregate was generally used in all tests to determine effect of form and size of column, type of reinforcement, and the various methods of protection. In the second, granite pebbles predominated with smaller proportions of gneiss and quartz, and the third consisted almost entirely of white quartz pebbles fairly well graded as to size.

As applied in round columns with 1 per cent spiral hooping and 2 per cent longitudinal reinforcement, approximately equal fire resistance was developed by columns of concrete made with the three aggregates. Failure under working load generally occurred after three to four hours' fire exposure. The cause of failure was spalling of the protec-

Fig. 8—Concrete protections, tests Nos. 35 to 39 and 45, after fire test

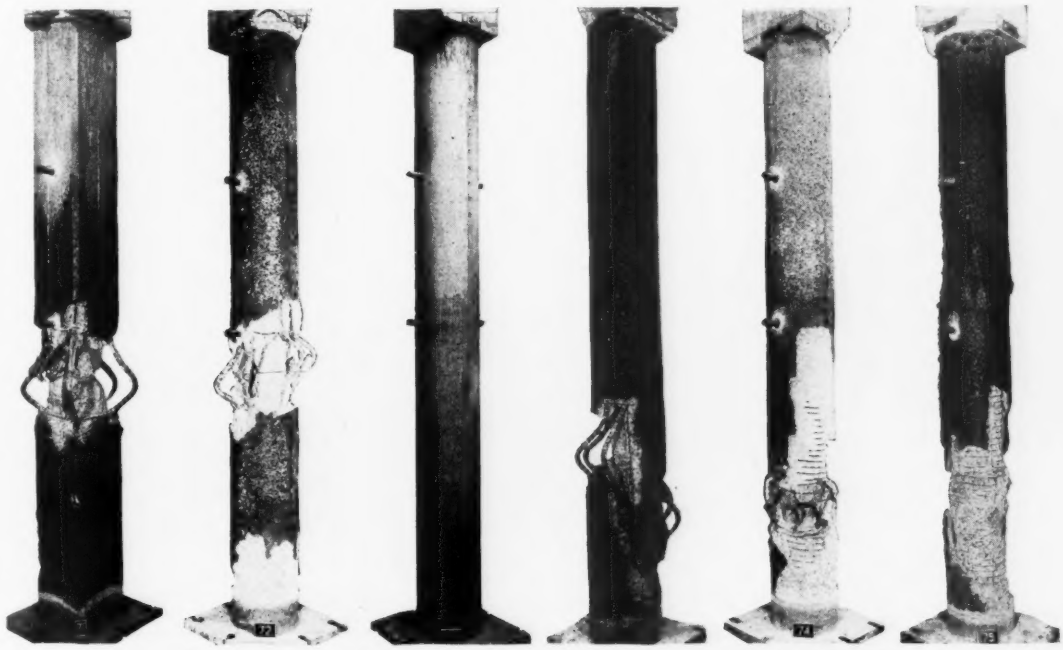


Fig. 9—Reinforced concrete columns, tests Nos. 71 to 75, after fire test

tion outside of the reinforcement which began about 30 minutes after the start of the test. This spalling was somewhat less pronounced and a little higher fire resistance was developed in case of round and square columns reinforced with longitudinal bars without the spiral hooping, due apparently to the absence of the plane of cleavage defined by the spiral hooping, and possibly also to the lower unit working load applicable for columns so reinforced. The round columns did not develop greater fire resistance than square columns of the same area, and same type of concrete and reinforcement. Two round concrete columns without reinforcement developed fire resistance under working load for plain concrete comparable with that of reinforced columns under their higher allowable unit loads. In the matter of effect of size in two tests of 12-in. spirally hooped and vertically reinforced columns, one failed after 2 hours' fire exposure and the other withstood the fire test for 4 hours and sustained 40 per cent additional load before failure. It should be noted that the working unit stress on the whole area was considerably smaller for the 12-in. columns than for the 18-in. columns, due to greater proportion of concrete considered as protective covering.

Light expanded metal placed in the 1½-in. protective concrete outside of the spiral hooping retained the protection in place suffi-

Fig. 10—Concrete protections, tests Nos. 101 to 103, after fire and water tests

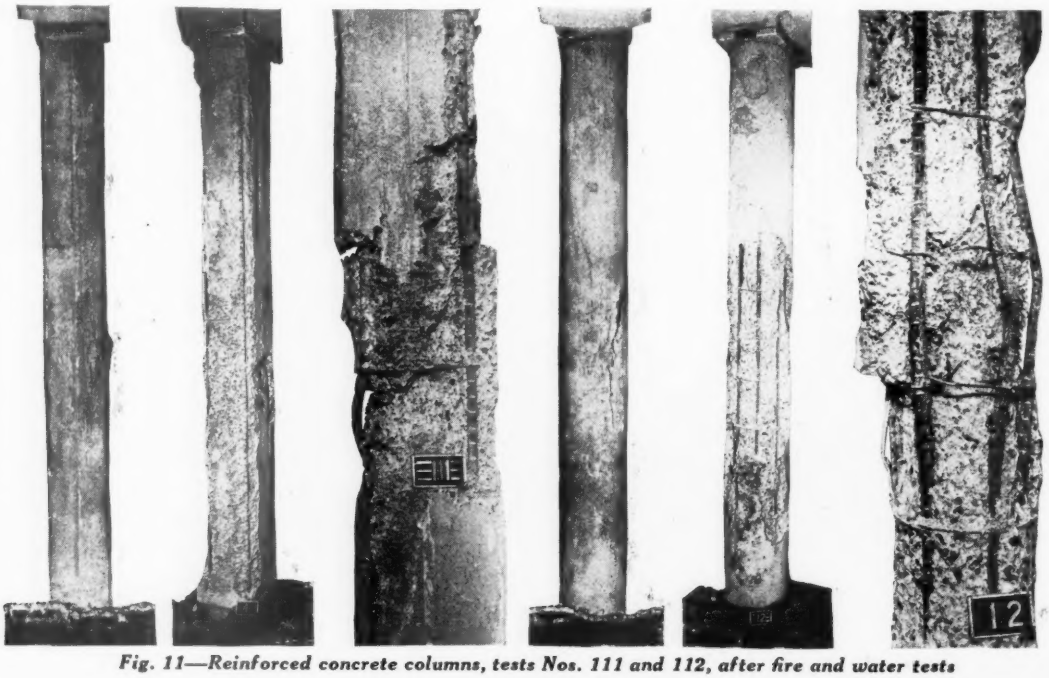


Fig. 11—Reinforced concrete columns, tests Nos. 111 and 112, after fire and water tests

ciently to enable 18-in. round columns of silicious aggregate to sustain working load for the 4-hr. fire exposure and while hot, loads averaging about 2000 lb. per sq. in. With 2½-in. protection of concrete but without a metal binder in it, the average load sustained at the end of the 4-hr. fire test was 1567 lb. per sq. in., and with a load and 50 per cent of the unexposed strength. A limestone concrete column reinforced with hooping and vertical bars and protected by 1 in. of plaster in addition to the 1½ in. of concrete suffered little permanent loss in strength due to the fire test.

In all tests with concrete made with calcareous aggregates no cracking or spalling

TABLE 42h. RESULTS OF FIRE TESTS—REINFORCED CONCRETE COLUMNS—EFFECTIVE LENGTH, 12 FT., 8 IN.

Test No.	Section	Outside dimension and reinforcement	Concrete—Mixture	Concrete—Kind	Age, days	Load sustained during test, lb.	Time to failure, hr.—min.	Furnace exposure, pct.
70	Square vertically reinforced	16-in. square..... Four 1-in. sq. bars	1:2:4	Chicago limestone.....	433	101,000 ‡294,000	8—40¼	101.1
71	Square vertically reinforced	Same as No. 70.....	1:2:4	New York trap.....	450	101,000	7—22¾	99.2
72	Round vertically reinforced	17-in. diameter..... Six 1-in. sq. bars	1:2:4	Chicago limestone.....	520	107,500 ‡250,000	8—04½	102.1
73	Round vertically reinforced	Same as No. 72.....	1:2:4	New York trap.....	442	107,500	7—57½	98.5
74	Hooped reinforced	17-in. diameter..... Six ¾-in. sq. bars ¼-in. ϕ spiral on 1½-in. pitch	1:2:4	Chicago limestone.....	522	129,000 ‡243,000	8—06½	99.5
75	Hooped reinforced	Same as No. 74.....	1:2:4	New York trap.....	460	129,000 ‡163,000	8—01¾	100.7

‡Load necessary to cause failure of column. After 8 hr. the load was increased until failure occurred.

metal binder imbedded, these columns tested cold subsequent to a 4-hr. fire test developed strengths comparable with that of similar columns tested cold without previous fire exposure.

A variable amount of resistance was afforded by columns with plaster protections applied to the column directly with or without metal binder, or as a form within which the column was cast. All afforded some protection enabling the columns to sustain working load for 4 hr., with substantial increase in load before failure at the end of the period.

(b) Concrete of Trap Rock and of Blast Furnace Slag

Round columns of concrete made with these aggregates and reinforced with hooping and vertical bars, and square columns of the same aggregates with vertical reinforcement, withstood the fire test under working load for 4 hr. and when further loaded at the end of the test failed under loads between 3 and 4 times the working load. Little cracking, spalling, or similar effects were apparent before failure, although the strength of the column while hot at the end of the fire exposure was reduced to about 50 per cent of that of comparable unexposed columns.

(c) Concrete of Calcareous Aggregates

The 18-in. round columns of concrete made with crushed limestone or calcareous gravel and reinforced with hooping and vertical bars withstood the 4-hr. fire test with loss of about 21 per cent of the unexposed strength as tested after cooling. They withstood, while hot, the maximum load that could be applied with the equipment (3400 lb. per sq. in.). Round and square columns of limestone concrete reinforced with vertical bars failed at the end of the 4-hr. fire test under loads averaging 2278 lb. per sq. in., which is about four times the working

of note developed and the temperatures in concrete and reinforcement were generally lower than for columns made with the other aggregates.

Generally the tests show quite conclusively that the fire resistance of reinforced concrete columns is mainly a function of the mineral composition of the concrete aggregates employed. Silicious aggregates will cause early cracking and spalling of the protective concrete on exposure to fire, leaving the load-bearing steel and concrete exposed. Substantial increase in fire resistance for such columns can be obtained by the use of outside plaster coatings suitably held in place, as also by imbedding metal mesh in the outer protective concrete. Concrete columns made with non-silicious aggregates, like trap rock, are neutral in this respect, but lose considerable strength on exposure to fire for several hours. As made with calcareous aggregates, the loss in strength is less than with concrete made with the other aggregates, due to the better insulation afforded, the heat-retarding effect of the calcination as such, and greater inherent strength of the concrete at temperatures below those causing decided calcination of the aggregate.

Discussion of Paper

By W. A. Hull, Physicist, U. S. Bureau of Standards

I THINK that is all I need to say. Those of you who are interested can get the information by writing the Bureau of Standards. I am condensing this book quite a little, and this one is already condensed quite a bit. Write to the Bureau of Standards and tell us the sort of information you are after and we can furnish you with some copies of that literature. I will be glad to give you the number, "Fire Tests of Building Columns," Technologic Paper of the Bureau of Standards, No. 181. There is another one that I referred to, a comparison of the heat-insulating properties of some of the materials used in fire-resistive construction—Bureau of Standards Technologic Paper 130. The work done at Pittsburgh has not as yet been published by the bureau, but it will be. A fairly complete resume may be found under the caption, "Fire Tests of Concrete Columns," Volume 16, 1920, American Concrete Institute. Also, I have a number of reprints of that, that I can send anybody who cares for them.

MR. STAHL: I would like to ask if an analysis was made of the limestone contained in the aggregate.

MR. HULL: We didn't make any analysis. It was a very well-known limestone, known as the West Winfield limestone, from Winfield, Butler county, Pa. It is a high calcium limestone.

MR. STAHL: I asked that question for the reason that a short time ago we were furnishing crushed limestone for the construction of a smokestack, a very compact body of concrete, and a very high one—I think it was some 300 ft. high. The parties who had the contract for that stack were not permitted to use high-grade limestone, where it came in direct contact with the heat, and I was interested to know why they declined to use our limestone where heat came in direct contact with it. It is a high-calcium limestone.

MR. HULL: They will look up the information and find the high-calcium limestone will stand a considerable fire damage before it starts to decarbonate. The temperature for rapid decarbonization for high-calcium limestone is about 900 deg. C., and magnesium limestone is lower. Consequently, the magnesium limestone will give probably a little better result in fire tests because the decarbonization of the limestone helps to save the life of the inner concrete. It is a heat-absorbing process, the decarbonization of limestone. Consequently, what it absorbs can't get through into the concrete.

After the limestone has decarbonated, it is a better heat insulator that it was before. That explains, I think, why our limestone concrete doesn't heat up as readily as the other kind. On the other hand, we get strength results in our fire tests that are not explainable entirely by the difference in temperatures.

Chimney Failure Explained

W. G. SWART, of the Messabi Iron Co., Babbitt, Minn., who has had extensive experience as a mining and smelter engineer, subsequently explained the cause of the concrete chimney failure referred to above. He said he had had a similar experience with a smelter chimney and the was accounted for by the action of the disintegration of the limestone concrete acid sulphur dioxide gases in the smoke on the limestone. Limestone is dissolved by sulphurous acid, resulting from a mixture of steam and sulphur dioxide.

Agricultural Limestone and Land Reclamation

By John T. Woodruff
Attorney, Springfield, Mo.

THE subject "Agricultural Limestone" is not of my own choosing; it was wished upon me by our energetic and persuasive chairman, Mr. Rockwood. Rather would I have chosen "Lime and Land Reclamation," as I regard the reclamation of the depleted and impoverished farm lands of the United States as our most important industrial problem.

The American farmer for a long period looked upon the public domain as affording limitless quantities of land at nominal prices, and felt no restraint in subduing virgin soil, and more often than not put new land under cultivation rather than properly husbanding the old. This policy has resulted in millions of acres becoming impoverished to such an extent that it costs more to produce a crop upon it than the crop is worth. It has also resulted in the abandonment entirely of thousands of acres in every state in the Union, which, if properly tilled and cared for, would be producing good crops at a profit.

The trouble with the farming industry today is not so much the temporary low price of farm products as it is the permanent high cost of producing them, but both problems are acute and require intelligent treatment.

In reckoning the cost of production a return on the capital invested must be allowed, the high wage paid for labor must be included, as well as the excessive cost of machinery and supplies, and taxes; but, figuring these items in, large as they are, a profit rather than a loss should result if the land would yield what it should yield. The Danes produce, on land no better than our own naturally, an average of 48 bushels of wheat per acre; our production in 1921 fell to about 13 bushels per acre. If our production per acre could be stimulated to half that of the Danes, which is altogether possible, farming would be as profitable as it has ever been, and with the modern methods of carrying on the business, would be as attractive as any of the other gainful occupations.

Is it strange that a man will quit the farm when he does not make both ends meet? Is it not the thing he should do? I for one think it is, and I am not one of those who believe the country is going on the rocks because so many are leaving the farms. This period of depression may be a process of eliminating the unfit. If it is, it may go too far. It is not likely that we are through with it. It will help some to provide credits available to the farmer, but not much; on the contrary, it may happen that if credits become easier than they now are, much money will be needlessly borrowed and unwisely spent. There is not a large percentage of farmers who can invest borrowed money in their business profitably. The farmer has helped his situation some by observing the "Buyers Strike." Exorbitant prices of supplies have been lowered a little by this method, but it is neither wise nor wholesome to carry it to extremes. Collective buying through purchasing agencies is a far better plan. Co-operative marketing is the best plan yet tried, to secure more equitable prices for farm products, and that plan is destined to become a big factor in our economic affairs. There is good reason to believe that through this plan, when backed by co-operative financing, which is also feasible, the farmer will be able to name the selling price of his commodities.

But, back of these things is the basic and fundamental necessity of producing more on fewer acres and thereby lowering the cost. This can be brought about solely and only by coaxing the soil to yield more abundantly. This result will not be brought about by the near-farmer who is serving time on his own or some other man's land, caring naught for the soil or the things growing thereon, invariably leaving his implements or husbandry to the elements, and the outcome of his crops to chance.

And, in saying this, I am not decrying the business of farming. I believe that civilization here and everywhere begins and ends with the plow. It is honorable and elevating to till the soil, and I do not, and neither do you, believe the imputation that Adam was visited with a curse when told that "In the sweat of thy face shalt thou eat bread." Rather has the injunction proven the salvation of the race. The man with the hoe has ever held his own, and saved the day when it was saved at all. He is the savior in Russia today. The Red regime in Moscow has put some 800,000 of them to death, but they have dug themselves in at last and are telling Lenine and his co-conspirators that they will not budge another inch along the communistic path, and they will not. Domination by the farmer in Russia is inevitable, and good government, as government goes in Russia, will result.

Farmer the Biggest Business Man

The farmer is the one essential member of civilized society the world over. Witness what the farmer has accomplished and what his enterprise stands for in this country:

The value of farms and farm property in the United Etates is	$77,924,000,000
The capital invested in manufacturing industries is	44,569,000,000
The Interstate Commerce Commission's valuation of all railroads is	18,900,000,000
The total capital, surplus and undivided profits of all banks in the United States, is	6,534,949,924

The value of our farms and farm property is more than the capital invested in all the other industries, including railroads and banks combined.

No industry is in a hopeless plight when it can dispense with 5 or 10 per cent of those engaged in it, as has been done recently, and suffer little or no loss in the gross output. This clearly shows that it is possible to stimulate production, and the aim should be to stimulate it vastly more, which can be done by fertilization.

The Department of Agriculture at Washington ,the agricultural colleges and experiment stations in every state in the Union have been pointing the way to greater production through the generous use of agricultural lime and limestone for years. About one-half of the soils of the country are now acid, and much of the land not now acid is becoming so every year. The one great remedy to neutralize this acid condition and restore fertility is limestone. Wherever we find plenty of lime in the soil and adequate moisture, there we find the strongest people, the best live stock, the best pastures, the biggest crops, the best farms and the most prosperous towns. It is worse than futile to attempt to raise good crops on acid soil. It would be far better for the farming industry to let the acid soils revert to the virgin state than attempt to cultivate them without restoring their fertility by the use of lime, for profitable crop production otherwise is impossible. The soil is a storehouse rich in all things necessary to sustain life, but it can be depleted until it is a barren as old Mother Hubbard's cupboard.

The foundation of successful farming and national prosperity is a maximum yield on every acre cultivated. Assuming that even 40 per cent of the tillable lands of the country are acid, which is 10 per cent lower than actual conditions warrant, and that this 40 per cent is being farmed without resultant profits, it is readily seen that the other 60 per cent is carrying the industry. The aim should be to restore or reclaim this lost 40 per cent, which represents more than 115,000,000 acres.

Use Limestone

The method of doing this in practical

husbandry is to apply a minimum of two tons of crushed limestone per acre the first year, with one ton added for each of the two years succeeding. Unless unfavorable conditions obtain, the cost of these applications should not exceed $4 per ton, or $16 per acre. Experiments carried on over a period of years at the leading agricultural colleges and experiment stations of the country show an increased yield in wheat and other small grains equal to 50 per cent, and from 50 to 100 per cent in clover, alfalfa, and other forage crops. Soil thus treated and properly tilled is not only reclaimed, but remains fertile and productive indefinitely.

In practice, an investment of $16 per acre distributed over a period of three years will yield a return of over 100 per cent on the investment, besides reclaiming soil which was valueless because unproductive before treatment, making it an asset of real value after treatment.

I have said the price of ground limestone should not exceed $4 per ton, and this price is liberal enough for the product at the farm. No producer of crushed limestone anywhere in this country ought to ask more than $2 per ton for ground limestone, and many plants ought to offer it for less, and no railroad should ask a rate of over $1 per ton for a haul of 100 miles or less, thus leaving $1 per ton for delivery from the railroad to the farm. If it be urged that freight rates exceed $1 per ton per 100 miles, the answer is that the rates are too high and they should be reduced. And here is an opportunity for some of our politicians to render a real service. If they want to live up to their profession, let them prevail upon the rate making authorities to establish and maintain equitable freight rates on crushed limestone and fertilizers. Such work will far exceed any drastic legislation having for its object the ham-stringing of the railroads or other corporate enterprises.

Greater Production on Fewer Acres

It is fallacious to claim that fair prices for farm products can follow in the wake of industrial depression. Let the wheels go round; put the idle men to work constructing railroads and highways, business buildings and dwelling houses, building factories and making goods, and every man, woman and child every day will eat three square meals and the country will stay on full rations. That is the other panacea for the farmers' ills, greater production on fewer acres being the other.

We must get it into our heads and keep it there, that if we are to have prosperity on the farm it will come only as a result of the farmers doing their part without the coddling or wet-nursing the politicians propose. Such a course means that the farming industry will rest upon a firm, not a fictitious, foundation. And you crushed-stone operators, each one and every one, must do your whole duty—put out a good product and offer it at a fair price. This is the one thing needful, and if you are made of the stuff we all think you are, you will see to it that your part in the program is cheerfully performed.

Reducing the High Cost of Accidents

By Sidney J. Williams
Chief Engineer, National Safety Council

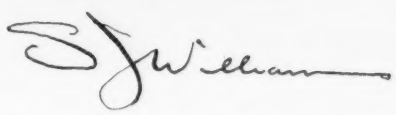
A COUPLE of years ago Herbert Hoover, a very practical man who has amassed a fortune as a manager of industrial enterprises, appointed a committee of prominent engineers to make a survey and report on "Waste in Industry." This report contains some interesting reading for any industrial executive who would like to save money. One of the points mentioned is this: That American industry pays more than one billion dollars per year as the direct cost of industrial accidents, not to mention other costs resulting indirectly which are probably as great or greater in magnitude.

It is stated in the report—and this statement has never been challenged—that, judging from the experience of a number of individual companies in various industries, at least 75 per cent of this enormous cost could be saved.

Accident Tax Big in the Industry

I do not know how much of this billion-dollar-accident tax is levied on the crushed stone industry, but your share is not a small one. You have the honor of being in the "hazardous" class. Your liability insurance rate is as great, or greater, than the rate for any of the building trades—another hazardous industry—excepting steel erection. It is nearly twice as great as the rate for steel works and rolling mills—always looked upon as hazardous—and many times greater than the rate for ordinary manufacturing industries.

In Illinois you pay, for workmen's compensation insurance, more than $7 for every hundred dollars of payroll. In other states having more liberal compensation



laws, you pay more—perhaps twice as much. In other words, if your payroll amounts to $100,000 per year, you pay at least $7000 for insurance, and perhaps a good deal more.

These insurance rates are, of course, based on experience—on the insurance companies' records of the number of deaths and injuries which occur in your industry and the amount of money paid as compensation. I do not have these insurance records at hand, but the government reports bear out the statement that your industry is a hazardous one. Each year, out of every 1000 men working in your industry, 2 are killed and 170 are injured, so that they lose at least one day's time. If we compare this with other hazardous work we find that in the extremely dangerous business of coal mining, with its terrible explosion catastrophes, the fatality rate is only twice as great—about 4 per 1000—and about 3 per 1000 in metal mining. In the iron and steel industry, including blast furnaces and rolling mills, the death rate in 1907 was just about equal to yours today—but today the iron and steel rate is only one-quarter as great!

How Steel Industry Reduced Its Death Rate

How has the steel industry accomplished this remarkable reduction?

Back in 1907 a few men in the steel industry conceived the revolutionary idea that, aside from any legal or moral obligation, it was bad business—expensive business—for them to permit their employes to be killed and injured. Accidents were expensive, they found, not only because they brought about

claims and damage suits, but because they interfered with orderly production. That statement was true then and it is even more true today when our compensation laws make every serious accident a claim which must be paid either directly by you as employer, or by your insurance carrier out of the premiums which he has collected from you.

So in a few pioneer steel plants they began to study accidents, not from the legal standpoint of how to evade claims but from the practical standpoint of how to prevent them. First they put their own house in order; they guarded their machines, put up railings, improved the lighting, etc. These measures had some effect, but the great bulk of accidents continued, being due to some ignorant, thoughtless or unsafe act on the part of the man who was hurt, or a fellow workman, or perhaps a foreman.

So they started a definite campaign to eliminate these non-mechanical accident causes as well as the mechanical ones. The method followed was a combination of supervision and education and, as modified by experience, may be briefly outlined as follows:

In the first place, safety must begin at the top and must have the active support and interest of the president or manager of the company. Men like E. H. Gary and Charles Schwab—the men in authority in their companies just as you are in authority in your companies—have definitely gone on record to the effect that accident prevention is an established policy of the company. This is essential because, naturally, the attitude of the chief executive is reflected all down the line. The "big boss" must first do all he can for safety before he can ask the co-operation of his men.

In the second place, in each company and in each plant some one man must be made responsible for safety. In a large plant this man will be the safety engineer or safety director. In a small plant this responsibility will be carried by the superintendent, and he may designate some mechanic or other employe to do some of the detail work, such as making a safety inspection at regular intervals, posting the safety bulletins in a proper and attractive manner, investigating any accidents or near accidents that occur, etc.

In a fairly large plant it is customary to have a general safety committee composed of executives to direct and co-ordinate the various safety activities. A foreman's safety committee is often used, and safety committees of workmen have been found valuable for the purpose of making supplementary safety inspections and correcting unsafe practices. In a small stone-crushing plant these committees are generally unnecessary; the superintendent and some employe designated by him as "safety inspector" are all the "organization" that is needed.

Finally, a definite and persistent effort must be made to secure the co-operation of the workmen. This does not mean a continual shouting to "be careful!" It means making sure that every workman, particularly the new man and the non-English speaking man, understands how to do his work safely. It means making a few simple rules for safe operation, and enforcing those rules with discipline if necessary, the same as any other operating rule. It means the use of safety posters or bulletins and other special schemes to bring home to the workman what it will mean to himself and his family if he is killed or seriously injured, and thus gradually to mold his mind in the safety pattern. It means giving safety a definite place in your operation.

One special educational scheme is the competitive "no-accident week" or "no-accident month" in which departments or plants are pitted one against another, or against their own past record, in the effort to keep accidents at a minimum. This arouses the competitive spirit and the co-operative spirit and is always successful if properly handled and if followed up with continuous attention to safety, the year round.

These methods—a combination of mechanical safeguarding, supervision, and education—are the tried and accepted methods of accident-prevention today and they are substantially the methods that in the steel industry have brought about the reduction already referred to, of about 75 per cent in the fatality rate and at least 50 per cent in the total accident rate. This is the average for the whole industry including, of course, some laggards. Individual companies have made much better records which I could quote in detail if time permitted. As one striking example, the United States Steel Corporation states publicly that its safety work has saved the company a million dollars a year, above all expense of mechanical improvements and educational work.

I have mentioned the experience of the steel industry because it is in many ways comparable to your own industry. It is hazardous; it includes much out-of-door work; it uses very heavy machinery and handles very heavy materials. It does not use explosives as you do, but it has a very serious molten-metal hazard. In quality of labor and in labor turnover it has, I believe, fully as much to contend with as you have. Yet despite these serious difficulties it has accomplished these remarkable results—and you can do the same.

Hazards of Construction

In one respect the steel industry is very different from yours—it is organized in much larger units. Therefore let me refer briefly to another industry—construction. Construction work is carried on not only in scattered and isolated places, but in places which are constantly changing and with gangs of men which are constantly changing, too. For these reasons, building contractors long believed that they could not use the safety methods used in the steel industry and in manufacturing. Building contractors used to explain to me quite convincingly how safety work could not possibly be done in their industry—until, a couple of years ago, some one came along and did it!

During the last few years a number of construction companies operating scattered jobs all over the country, some large and many small, have reduced their accident rates and costs by 40, 50, and even 75 per cent, by these same methods—modified a little, of course, to suit the circumstances, but essentially the same as I have described, for they are dealing with the same sort of human being who is very much alike under the skin, whatever his trade or nationality or station in life—who loves his wife and family, does not want to see them in distress; does not want to suffer the pain and the wage loss caused by an accident, and is, generally speaking, quite willing to become a safe worker when once the idea has become firmly planted in his mind.

By thus reducing their accidents, many construction companies have secured reductions of 20 or 40 per cent, or even more, in their insurance rates, through the operation of the experience rating plan of the insurance companies. You can do the same.

Code of Safety Rules Recommended

Perhaps you wonder that I have not described to you the specific hazards of your industry and the corresponding preventive measures. According to the records, your principal hazards are in connection with the handling and use of explosives; drilling; handling rock at the face of the quarry; loading and transportation of rock on cars; and at the crusher. Poor condition of floors, stairs, railings, electric lights, etc., is often a contributing factor. I could discuss some of these hazards with you in detail or I can furnish you publications of the National Safety Council on the subject, written by men more familiar with your operations than I am.

It would be an excellent plan for your association to appoint a committee to prepare a code of safety rules for the industry, such as the Industrial Commission of California has prepared for quarries in that state. The National Safety Council would be glad to give assistance to such committee.

The National Safety Council is a co-operative association, organized and operated on a business basis, composed of over 3100 members, most of whom are industrial employers like yourselves. Our membership already includes 17 companies in the quarry industry. We are glad to give you, either as an association or as individual companies, any assistance and information that we can, either on specific hazards or on general methods of safety organization. We shall count it a privilege if we can help you to reduce this enormous and needless waste of life and money in your industry.

Stone Screenings as Fine Aggregate for Concrete

By Duff A. Abrams

Professor in Charge of Structural Materials Research Laboratory, Lewis Institute, Chicago

THERE is probably no question in the whole category of concrete testing which raises so many knotty problems as that of the determination of the relative merits of crushed-stone screenings and natural sands as fine aggregate for concrete. It brings us back to the question of what concrete is and the underlying principle on which the proportioning of mixtures is based and the many details of testing of aggregates and concrete. The methods of testing are very important features of any discussion of the relative merits of different materials in concrete. In other words, if our tests are not carried out in an absolutely comparable manner, we are almost certain to get misleading results and may arrive at entirely erroneous conclusions.

Concrete is a mixture of cement, aggregate and water. Too often the water is entirely overlooked in our discussions. We go to great lengths in testing cement and in examining aggregates, but pay no attention to the quantity of the mixing water.

Investigations carried out at the Lewis Institute in co-operation with the Portland Cement Association during the past eight or nine years have given us a great deal of new information on the underlying principles of concrete mixtures and on many related topics. These investigations have shown that the *quantity* of mixing water is by all odds the most important factor in a concrete mixture. Wide variations in the type or size and grading of aggregate and in the quantity of cement, make much less difference in the strength and other properties of the resulting concrete than do slight variations in the quantity of mixing water. This consideration of the effect of quantity of mixing water has a most important bearing on the relative merits of screenings and natural sand; if we do not get the proper balance between the water content in the mixtures, we are certain to get results which reflect that variation rather than the effect of the shape and size of the aggregate article.

The general characteristics of aggregates for concrete are: (1) structural quality—that is, they must have a certain degree of hardness, toughness and general durability, whatever we term it, that will enable them to withstand the stresses which come upon them and to resist exposure to weather, etc.; (2) cleanness; freedom from excessive amounts of clay and dust and from organic impurities such as may occur in surface loam; (3) size and grading, depending on the mixtures used and the type of work under way; (4) shape of the particles.

The only question at issue here is the effect of shape of particles, since we must consider that the aggregates are of similar structural quality and similarly graded, or we are not working on a uniform basis. Natural sands and gravels differ from crushed rocks only in that they have been broken down and in general the particles are rounded by natural agencies. The principal agencies in the production of sand and gravel are, no doubt, glaciation, stream action and weather. Those causes will probably account for formation of sand and gravel, so that we are dealing

with the same materials, except one has been rounded and the other has not.

We have studied the relative merits of screenings and sands to some extent, not to as great an extent as we desire, and not to a sufficient extent to clear up all of the problems that arise.

In dealing with concrete mixtures, there is always a question as to just what quality of concrete we are trying to secure. All concrete work must be done with a consideration of durability and cost. We cannot get away from those two limitations. If concrete is not durable it will be disappointing in the end; if it costs too much we cannot afford to use it. There are also the important questions of strength, wear, water-tightness, ease of placing, ease of finishing, resistance to various destructive agencies and appearance.

So far as most of these topics are concerned, there is little room for choice between screenings and natural sand. However, when we come to such topics as water-tightness, ease of placing and ease of finishing, difficulties are sometimes encountered.

During the past three or four years we have carried out four separate series of investigations in which comparisons were made between the relative merits of natural sands and screenings. These tests apply only to the *strength* of the resulting mortar or concrete and do not constitute a complete investigation of the subject.

Record of Tests

SERIES 2. This series includes tension and compression tests of 1-3 mortar at 7 and 28 days, using about 1300 different samples of fine aggregates from widely scattered sources. These samples were sent to the laboratory for test during the period 1914 to date. For about 800 of the early samples, briquets of 1-3 mortar by weight were tested at ages of 3, 7 and 28 days; for the remaining 500 samples, 3 x 6-in. or 2 x 4-in. mortar cylinders of 1-3 mix by weight or by volume were tested in compression at 7 and 28 days. Among these samples were a large number of stone screenings. Due to the fact that these tests extended over a long period of time, it was our practice to make parallel tests, using standard Ottawa sand on each day that other fine aggregates were tested.

It is impracticable to give all the details of these tests in this report; however, the principal conclusions, so far as our present inquiry is concerned, may be summarized as follows:

1. The amount of mixing water used and the manipulation of the mortar may affect the strength more than the grading or type of the aggregate used.

2. For mortars of similar consistency, the strength varied with the grading of the aggregate as measured by fineness modulus. The higher the fineness modulus (coarser the grading) within certain limits, the higher the strength.

3. Other conditions being equal, aggregates of same fineness modulus gave about the same mortar strength at 7 and 28 days.

4. In general, screenings are graded coarser than the average natural sands; hence, if the grading is not taken into account, the screenings will generally be found to give higher mortar strength than sands.

5. Mortar strength tests do not give definite information on the relative value of sand and screenings for concrete mixtures. There appear to be two reasons for this result: (a) The angularity of the particles in the screenings permit more tamping and consequently probably receive more in the molding of the test pieces than the sand. (b) In 1-3 mortars the screenings of sand constitute the whole aggregate, while in concrete mixtures these materials are only about one-third the aggregate, hence their influence on the final result is much less in concrete than on mortar mixtures. In the case of briquet tests, there is an additional reason for discrepancies in that the shape of the specimen and the resulting distribution of stresses give results entirely different from that found in compression tests of concrete. (This conclusion was reinforced by later series of tests described below.)

SERIES 84. Compression tests were made on 6 x 12-in. concrete cylinders at ages of 28 days and 6 months. Mix 1-5 by volume, relative consistency 1.00 (normal consistency). In this series the fine aggregates were limestone screenings and natural sand and the coarse aggregates crushed limestone and pebbles. Four combinations were used, as follows: Sand and pebbles, sand and crushed limestone, limestone screenings and pebbles, and limestone screenings and limestone. Twenty-seven different gradings of each of the above combinations were used. The size of the fine aggregates varied from 0 to No. 48 and 0 to No. 4; the coarse aggregate was of the same grading throughout and ranged from No. 4 to 1¼ in.

In order to secure a uniform grading, all aggregates were screened into several sizes and recombined by weight. The sand was largely of limestone origin from Elgin, Ill. As produced for the market, this sand is well graded up to about ¼ in. and is a high-grade concrete sand, known in the trade as "torpedo." The consistency of the concrete was judged by an experienced operator. Total of 432 concrete cylinders were tested.

Fig. 4 shows average relation between the grading of the aggregates, as measured by fineness modulus, and the compressive strength of the concrete at 28 days, for the gradings employed in this series. The fineness modulus is a measure of the size and grading of the aggregates; it is the summation of the percentages coarser than each of the following sieves: 100, 50, 30, 16, 8, 4, ⅜, ¾ and 1½ in., divided by 100. Aggregates in which the coarser particles predominate have a high fineness modulus and those in which the finer particles predominate have a low fineness modulus. (Fig. 4 on page 157.)

These tests show that the concrete made with natural sand and pebbles gave about the same strength as that from sand and crushed limestone. The concrete made with limestone screenings as fine aggregate gave considerably lower strengths. The lowest strengths were obtained with the screenings as fine aggregate and pebbles as coarse aggregate; the strength of concrete was about two-thirds of that from sand as fine as aggregate and pebbles or crushed limestone as coarse aggregate. The screenings required about 30 per cent more water for normal consistency than was necessary with sand, this increase in mixing water would be expected to produce about the reduction in strength indicated.

SERIES 145 (A). This series included tests of mortar and concrete made from about 200 samples of fine aggregates obtained from various parts of the United States and Canada, among which were natural sands, screenings from limestone, granite, trap, slag, chatts and other materials. Tension tests of briquets of 1-3 mortar (by weight) and compression tests of 2 x 4-in. cylinders of 1-3 mortars (by weight and by volume) were made at ages 7 and 28 days, 3 months and 1 year. Compression tests of 1-4 concrete in the form of 6 x 12-in. concrete cylinders were made at the same ages; wear tests of 8 x 8 x 5-in. blocks were made at 3 months. The coarse aggregate was pebbles graded from No. 4 sieve to 1½ in. from Elgin, Ill. The relative consistency was 1.10. This investigation included about 3800 briquets, 7600 2 x 4-in. cylinders, 3200 6 x 12-in. cylinders and 1200 wear tests—a total of about 15,800 specimens.

The principal results are given in Tables 1 and 2. In the preparation of the 1-3 mortar, care was taken to use the same consistencies throughout. The consistency was judged by an experienced operator and checked by a "flow-table" similar to that used by the Bureau of Standards. Somewhat wetter consistencies were employed in these tests than for standard tests of cement, in order to avoid the variation in results due to irregularly graded aggregates when mixed to a relatively dry consistency.

The natural sands and slag screenings had approximately the same average strengths at all ages and gave the lowest values of the materials tested. The stone screenings gave higher average mortar strengths than the sands; the different types of stone screenings gave essentially the same strengths. It should be noted that the average fineness modulus of the sands was smaller than that of the crushed materials, which would be expected to account for the differences in strengths. Attention should be called to the tests in Table 2, which show a different relation for the screenings when the same fine aggregates are used in concrete.

Table 2 gives the results of strength and wear tests of 1-4 concrete using the same fine aggregates given in Table 1, combined in each case with Elgin, Ill., pebbles graded from No. 4 sieve to 1¼ in. Tests were made on 6 x 12-in. cylinders at ages of 7 and 28 days, 3 months and 1 year; also wear tests on 8 x 8 x 5-in. blocks at the age of 3 months. The wear tests were made in Talbot-Jones rattler by methods described in Bulletin 10, "Wear Tests of Concrete," of the Structural Materials Research Laboratory. The consistency of the concrete was judged by an experienced operator and checked by the flow-table. A high value of flow indicates a more plastic or workable concrete than lower values.

In order to place the different fine aggregates on the same basis in the concrete tests, the relative amounts of fine and coarse aggregate were varied in such a manner as to give a uniform fineness modulus (5.50) for the mixed aggregate; the average percentages of the fine aggregates are shown in the table.

The compressive strengths of the concretes are seen to fall into two different groups: that made of sand, granite screenings and chatts gave nearly the same strength, and that made with limestone, slag and trap screenings gave about 12 per cent less strength at all ages. The wear at three months was also a little greater for the latter materials. It should be noted that a large number of natural sands were used and relatively few samples of screenings. In general more water was used with the limestone, slag and trap screenings for equal consistency than for sand, granite screenings and chatts. The use of a greater amount of mixing water accounts in part for the somewhat lower strength of the concretes made with the limestone, slag and trap screenings.

SERIES 145 (B). In order to determine the effect of mixing screenings with sand, a separate group of tests was made at the same time as Series 145 (A), in which limestone, granite and slag screenings were mixed with various percentages of a well-graded sand from Elgin, Ill. The coarse aggregate for these tests was pebbles graded for No. 4 to 1½ in., also from Elgin, Ill. In this investigation about 500 briquets, 1000 2 x 4-in. cylinders, 500 6 x 12-in. concrete cylinders, and 100 wear blocks were tested. The results of tension and compression tests of mortars and compression tests of concrete are given in Figs. 1, 2, and 3. (See page 157.) The wear tests are omitted from this report.

Fig. 1 shows the effect of quantity of sand in mixtures of sand and screenings on the tensile strength of 1-3 mortar. Except for the tests at one year there is not much change in tensile strength as the percentage of sand is increased up to 50 per cent; beyond this point the tensile strength decreased. The mortar strength with the sand only is less than for screenings only, except in the case of the slag screenings at the later ages. In the *mortar* tests a somewhat greater strength would be expected for the screenings, since they were graded coarser than the sand. The grading of the slag screenings was quite coarse and gave rather harsh-working mixtures in the 1-3 mortar.

The results of the compression tests of the 2 x 4-in. mortar cylinders of 1-3 mix by weight are given in Fig. 2. In general, they show the same result as was obtained for the tension tests.

The results of the compression tests of 1-4 concrete are plotted in Fig. 3. The fine aggregates were combined with pebbles so that the resulting fineness modulus was the same in each case (5.50). The consistency of the concrete was similar, as nearly as could be judged by a skilled operator. A relative consistency of 1.10 was used. In these tests the strength of the concrete increased uniformly with increase in percentage of sand in the fine aggregate. The increase in strength for the concrete made with sand alone over that made with screenings alone was about 12 per cent at 7 and 28 days and about 20 per cent at 3 months and 1 year. This result is the reverse of that found in the *mortar* tests and indicates that the concrete-making properties of the materials cannot be judged on the basis of mortar tests alone. A part of the difference in strength is due to the fact that the required consistency could be obtained with a somewhat smaller quantity of mixing water in the concrete made with sand.

A question which is often encountered in using screenings is the workability and ease of finishing, particularly in concrete roads. Dust in screenings in quantities up to, say 10 per cent, does no harm, so long as the concrete is well-mixed and of a proper consistency; too much mixing water causes the dust and other fine material in the concrete to float to the surface where it forms a weak, friable layer called laitance, or produces a concrete which is unable to resist wear and weather. I wish I could emphasize sufficiently the importance of a proper control of mixing water

in concrete; there is no feature of concrete making that is more important. Unfortunately, we allow the mixer foreman to use his own judgment in proportioning the water in the batch. It would be just as consistent to measure the water accurately, and guess at the cement, as it is to measure the cement and guess at the water. In general, we would get better results by guessing at the cement.

Care must be taken in any case in which screenings are used as fine aggregate to eliminate the quarry dirt. Dirt should not be allowed to fall into the quarry and be scooped up with the material as it is loaded and carried through the plant and into the screenings.

The writer had an opportunity to examine a concrete bridge in Nashville, Tenn., in which stone screenings were used as fine aggregate. This bridge showed very poor concrete, but it appears that the screenings have been improperly blamed for a poor job. In general, it is almost impossible to determine what was wrong with the concrete by a post-mortem examination, but in this case the poor results may be attributed to (1) sections too thin, particularly on railings; (2) screenings graded too coarse; (3) too much mixing water; (4) too lean mixtures; and (5) probably improper curing condition. Any kind of aggregate under those conditions would give poor concrete.

In closing it may be well to emphasize a few of the most important features of the results of our studies of the strength of mortar and concrete made from sand and screenings.

1. **Aggregate testing has not thus far reached the state of an exact science; in other words, available test methods do not always enable us to determine definitely the relative merits of aggregates of different types.**

2. **Mortar strength tests are likely to give misleading results, particularly when tension tests are made on briquets; due to the angularity of particles, the mortar from screenings probably receives more tamping than sand-mortars.**

3. **The strength of concrete made from screenings on the same basis is a little lower than the strength of natural sands.**

4. **Good concrete can be made with stone screenings as fine aggregate, but it is important that proper inspection be given to see that the material is graded in such a way as to be free from an excess of dust and of extremely coarse particles, and that an excess of mixing water is not used. Due to the angularity of the particles there is a tendency with screenings to use more mixing water than is required by sands; especially where concrete is distributed by chutes.**

5. **These tests and other investigations show that good concrete can be made from inferior aggregates, if proper proportions and manipulation are employed; on the other hand, very inferior concrete may result with the best of aggregates if improper methods are used. The quantity of mixing water is the most important feature of a concrete mix.**

6. **Additional studies are desirable in order to bring out the features of the relative merits of sands and screenings.**

TABLE I—MORTAR STRENGTH TESTS USING SAND AND SCREENINGS

The relative strength of the mortars is expressed as a ratio to the corresponding strength of standard Ottawa sand mortar of the same mix and same age

Fine aggregate	No. of samples	Fineness modulus	Water, cement ratio	Flow	Relative mortar strength — 7 d.	28 d.	3 m.	1 y.
Tension Tests of Standard Briquets, 1-3 by Weight								
Sand	87	2.69	0.78	141	1.37	1.18	1.21	1.42
Limestone screenings	11	3.14	0.80	136	1.69	1.50	1.61	1.99
Slag screenings	9	3.45	0.86	122	1.33	1.15	1.33	1.74
Trap screenings	3	3.37	0.77	125	1.89	1.70	1.79	1.99
Granite screenings	4	2.96	0.74	124	1.87	1.53	1.73	2.02
Chatts	10	3.62	0.71	120	2.01	1.74	1.85	2.16
Compression Tests of 2x4-in. Cylinders, 1-3 by Weight								
Sand	87	2.69	0.78	141	1.32	1.23	1.16	1.19
Limestone screenings	11	3.14	0.80	136	1.82	1.59	1.43	1.53
Slag screenings	9	3.45	0.86	122	1.22	1.10	1.08	1.20
Trap screenings	3	3.37	0.77	125	1.71	1.52	1.43	1.53
Granite screenings	4	2.96	0.74	124	1.68	1.56	1.49	1.49
Chatts	10	3.62	0.71	120	1.64	1.56	1.40	1.43
Compression Tests of 2x4-in. Cylinders, 1-3 by Volume								
Sand	87	2.69	0.85	135	1.25	1.16	1.03	1.18
Limestone screenings	11	3.14	0.92	133	1.73	1.41	1.33	1.56
Slag screenings	9	3.45	0.83	122	1.27	1.17	1.07	1.25
Trap screenings	3	3.37	0.86	125	1.48	1.43	1.19	1.41
Granite screenings	4	2.96	0.81	120	1.59	1.48	1.30	1.51
Chatts	10	3.62	0.76	125	1.58	1.48	1.28	1.40

TABLE II—CONCRETE TESTS USING SAND AND SCREENINGS AS FINE AGGREGATE

Compression tests of 6x12-in. cylinders. Wear tests of 8x8x5-in. concrete block. Mix 1-4 by volume. Coarse aggregate in all cases, Elgin, Ill., pebbles graded No. 4 to 1½ in. Mixed in such proportions that the total aggregate would have an equivalent grading as expressed by a uniform fineness modulus of 5.50. Cylinders cured in a moist room until date of test; tested damp. Wear blocks stored in moist room for 14 days; remainder of curing period in air.

Material	No. of samples	Fineness modulus m	Per cent for m=5.50	Weight of mixed aggregate, lb. per cu. ft.	Water, cement ratio	Flow	Compressive strength of concrete 6 lb. per sq. in. — 7 d.	28 d.	3 m.	1 y.	Depth of wear at 3 m., in.
Sand	87	2.69	36	126	0.79	210	1710	3050	4160	5330	.54
Lime screenings	11	3.14	41	122	0.89	198	1600	2610	3570	4680	.55
Slag screenings	9	3.45	44	115	0.87	192	1330	2430	3490	4690	.59
Trap screenings	3	3.37	39	123	0.92	202	1380	2430	3460	4550	.55
Granite screenings	4	2.96	38	124	0.84	198	1600	2830	3970	5180	.50
Chatts	10	3.59	45	118	0.82	196	1600	2620	4050	5290	.52

Accompanying curves—Figs. 1, 2, 3 and 4 are shown on page 157

Discussion of Prof. Abrams' Paper

PRESIDENT SCHMIDT: You speak of guessing at the water. Is there any visible method or can you give us an idea of approximately the consistency concrete is best?

PROF. ABRAMS: Well, it is always a safe rule to use as little water as you can get away with. That is the first rule. Just how much water that is, how much water that requires, obviously depends on a number of other factors. In other words, the type of work under way must govern to some extent; the type of aggregates, that is, whether it is fine sand or coarse sand will govern to some extent. The mixture used will govern to some extent. It is a pretty safe rule that about 5½ to 6 gal. of water per sack of cement is enough for ordinary conditions. In some instances you may be able to use less and in some instances you may have to use more; with a poor mixture you will have to use more and with a rich mixture less.

PRESIDENT SCHMIDT: Then as I understand it, 5 gal. of water to a bag of cement is better than guessing.

PROF. ABRAMS: Yes.

PRESIDENT SCHMIDT: I thank you. Any other questions?

J. H. CAMPBELL (Chicago): Do you find any difference in the amount of water used to bring the screenings to the same plasticity that you did for sand?

PROF. ABRAMS: Yes, there is a difference. In general, about 20 per cent more water is necessary in the ordinary concrete mixture.

MR. SAVAGE: I would like to ask if you advise the use of calcium chloride in cold weather and what the effect would be.

PROF. ABRAMS: I think the value of calcium chloride has probably been overestimated. We have made a great many studies of the effect of calcium chloride on the strength of concrete. It seems to depend on the kind of cement used. I don't know why that is, but some cements give you a very large increase in strength due to 4 per cent calcium chloride and some give very little increase and some none at all, and the effect varies with the age. The greatest effect occurs in the very early ages, about two or three days, and at the ages of 20 days or three months, the beneficial effect has entirely disappeared and at the age of one year or more the strength seems to be less.

As to the effect of calcium chloride on freezing, it undoubtedly does have some effect. I think the mechanism of that effect has been entirely misinterpreted. Two or three per cent of calcium chloride has very little effect in increasing the evolution of heat. In the mixture of calcium chloride with cement is the only place you get the effect.

"Our Industry"

By John J. Sloan
Secretary, the Wisconsin Granite Co., Chicago

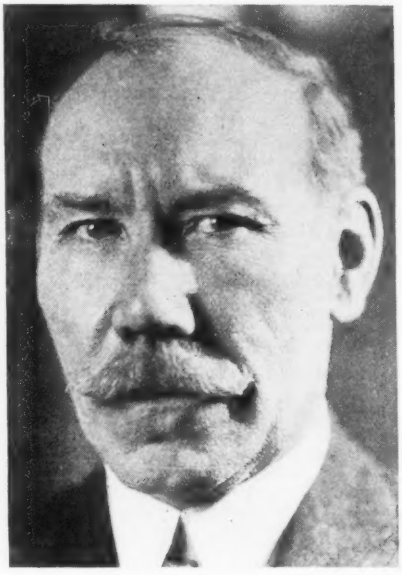
THE NATIONAL CRUSHED STONE ASSOCIATION, now entering into its sixth year of existence, representing an industry that has 2900 established plants employing annually a matter of 60,000 men, producing 150,000,000 tons at least, carrying a pay roll of $125,000,000 a year, with its ramifications extending from the coast of Maine down through the trap-rock districts of Connecticut, all down the New Jersey shore and around by the granite districts of North and South Carolina, coming up to the sandstone deposits and the blue grass state of Kentucky, and along by the Father of Waters, spreading out through the plains of the West clear into sections represented by the members present here tonight, whose plants are located within the shadow of the Mormon temple and others in the golden state of California; and even Canada, across the line, is represented. We certainly represent a wide extent of territory in supplying basic needs that enter into all human existence from the lime water that was probably fed to you as an infant to the concrete casket with which you may pass away.

Stone finds its uses in all the basic industries of the country, not only railroads, but all the steel and metallurgical trades and the production of sugar and of rubber and the building of roads and homes and houses; everything that enters into the gamut of human existence passes more or less through our hands; and related products so aptly typified in the thousand and one uses that our products enter into, in the chemical and allied trades, for aiding with fertilizer to grow the very food that you consume, to the feeding of live stock to build it up from its bony structure to carry the meat that later on we all enjoy; in all domains of human endeavor you do not get anywhere without the stone man.

You have been listening to a good deal of sober and serious discussion, matters pertaining to your industry for the past couple of days; note has been sounded at different times relative to some of the evils and troubles that we all complain of, and various suggestions are made from time to time by people who have given it some thought (or little thought) about matters that would tend to remedy and better conditions.

The Railways

We are fortunate in having at our board tonight men who represent the greatest industry in the world, for without it we would get nowhere, neither would our country have ever developed without those avenues of transportation that made it possible for us to distribute our products, which have helped to build up an empire. There are kings of finance and business—kings that we read about—but let me tell you in all sincerity that at your board tonight sit men who are kings of railroads, men of humble origin, as clerks and engineers in minor capacities, who have climbed the ladder of success and have finally reached that



pre-eminence which stamps them as kings of railroad men, and presidents of their respective systems, stretching over an empire, handling the destiny of hundreds of thousands of men and spending recklessly, if you will believe some of the reports, millions and millions annually.

That you may have an idea of the conditions that pertain to a railroad center like Chicago with its 39 railroads—26 of them great trunk lines—with 15,000,000 cars a year coming in, with 177 depots within the city, and with 150,000 passengers a day passing to and fro, carried in a matter of 1700 trains a day. It is but a part of the duties of these executives to supervise and to tend to the multitudinous affairs pertaining to these great systems.

I bespeak in these days of wild thought and sometimes wilder speech for a little realization of the problems of the other fellow. True, we have difficulties of our own, and as was stated at a meeting of ours yesterday, the coal industry of the United States increased in the last decade a matter of 36 per cent, but the tractive power as well as car supply of the railroads increased 54 per cent, while the coal mining units of the country increased 154 per cent. It is quite easy to understand then why cars are short at times when transportation systems are called upon to deliver to three units where they formerly delivered to one, in spite of the fact that their accretions and facilities for doing business increased to a greater capacity than the consumption of coal increased over a 10-year period.

We must find a solution for the problems that confront us in our transportation question, but no Sovietist systems, pauperized or subsidized systems can be ingrafted, in my opinion, upon the American body politic without doing a direct injury in the long run to all of us. We must have safe and sane legislation, regard for the other fellow's rights, removing the restrictions that tend to prevent large corporations of a public character, like public carriers, from carrying out their intent and their methods of serving; they are in business to serve you, they are in business to make money, but if you hamper and restrict the transportation system of the country as it has been definitely proven ever since we entered the war and since, you hamper and curtail your own activities to your own loss.

The Banquet

TOASTMASTER—Mr. John J. Sloan.
"Our Industry"

SPEAKERS OF THE EVENING

MR. W. H. FINLEY, President of the Chicago and Northwestern Railway:
"Transportation"

MR. C. H. MARKHAM, President of the Illinois Central Railroad:
"The Public's Interest in the Railroads"

DR. WILLIAM K. HATT, Director, Advisory Board on Highway Research, Division of Engineering, National Research Council:
"Mooted Questions in Highway Transport"

MR. W. SCOTT EAMES, President of the National Crushed Stone Association
"Our Association"

MR. S. L. SQUIRE, Official Representative of the Canadian Good Roads Congress:
"Hands Across the Border"

MR. JAMES H. MacDONALD, Treasurer of the American Road Builders' Association:
"The Good Roads Show"

"Transportation"

By W. H. Finley
President of the Chicago and Northwestern Railway

OUR great country was settled by the early pioneers when the only methods of communication or transportation were waterways, and those early pioneers from the seaboard up into the interior of the country followed the waterways and established their settlements and their lines of communication. It was the only method of transportation.

The hardier ones pushed out away from the rivers into the country and established settlements, but the only means of transportation or communication was the ox team that followed the trail, the Indian trail. True, in the use of our waterways in pioneering the country we established at different points, centers of industry that grew to such an extent that it was necessary to have some more rapid means of communication and transportation than the waterways, something that would bring into close relation those widely separated centers of industry, and in came the railroad.

I think the history of the development and building of the railroads of the United States is an epoch, something that some day will be written for your grandchildren to read with kindling eyes; that will show how their forebears were men of such vision and such courage, men who looked ahead so far and saw what our country meant and what its future development was going to be. They pushed the railroads across the country over the prairies, through the deserts, and they made two blades of grass grow where none grew before.

They staked their money and their lives in building the system of railroads. They had confidence in the future of the United States. The hardy New Englanders that had accumulated money in shipping, and when the shipping died out were still men of vision and progress, turned to the great West and put their money into the building and pioneering of the railroads of the West, and to say those men or their descendants are not entitled to credit, are not entitled to recompense for what they did, is denying every incentive to work for progress in this country.

The railroads continued to fulfill their destiny and functions as transportation systems; and now we have come to another day and another time when there seems to be a question as to the railroads of this country and whether they are fulfilling their destiny and functioning as they should. But I am optimistic, I still have confidence that we are going to come out all right; and at the present moment the railroad situation is fairly good.

One of the reasons, and that is not the least important, is that not much is being done about the railroads just now. I am not referring to the talk, gentlemen, the wild assertions that are made, but there is no actual legislation in view. Nowadays, the railroads are happy if they are simply let alone. If they could only be let alone long enough, they would quickly do their part

towards making everyone else happy. Most of the troubles that the railroads as a whole have ever had can be traced to interference in their affairs by some movement prompted by people who know nothing about railroads, but who think they do, and who feel it is their duty and mission in life to set the railroads right.

Condition of Equipment on the Northwestern on January 15, 1923

We feel on the Northwestern that we have made quite a good recovery from our most recent illness. For instance, we have now 1650 locomotives in good working order and only 400 out of service for repairs. I am going to mention briefly about equipment because that is what you people are interested in.

About the middle of September, when conditions were at their worst, we had only 1350 locomotives in good order and 700 out of service for repairs. Our power has not at any time in the past five years been in much if any better shape than it is now. We still have more engines in bad order than would be ideal. If we were in an ideal condition we would have about 12 per cent, or 250, in the shops getting repaired and none waiting. As it is now 20 per cent are out of service. Of this number we have 250 actually in the shops getting repaired, for that is the capacity of our shops, while the other 150 are waiting outside for their turn in the shops. We are exercising every effort, sparing no expense to clean up this waiting list. We have now about 10,000 employes in our locomotive shops while 8500 is a normal force for us, but notwithstanding this we feel that we are now in such fair shape that there is nothing to fear if, as I said before, we are let alone for a while longer.

Our cars also have been through the same experience as our locomotives. We now have about 70,000 freight cars on the road; of these 4550 or a little over 5½ per cent are in bad order, undergoing repairs. At the middle of September nearly 8000 were unserviceable, so you see we have reduced the waiting list about 3000 cars since that time. We regard five per cent or about 3500 bad order cars as an ideal condition, so that we still have to dispose of an additional 1500 surplus bad order cars. It has been a long time since we have been down to five per cent but we hope to get there again. We have been as low as six per cent several times in the past three years. Most of the time the bad order cars have amounted to between seven and eight per cent.

The Northwestern now owns about 70,000 freight cars. This ought to be enough to care for our needs. Of course, they are not all new, modern cars but they are all serviceable and we are buying new cars in as large a quantity as it is possible for us to do. We purchased last year over 5000 new freight cars. Freight cars last on an average of 20 years, so that 3500 cars each year takes care of the mortality; and we provided about 40 per cent more than last year's replacements required. That was some of the slack accumulated in the past five or six years to provide for and to some extent for added business and also to modernize our facilities. We have also contracted for delivery this year 3000 additional freight cars, making a total of 8000 freight cars in the two years.

Average Car Service

Now I think 70,000 freight cars ought to

be enough for the Northwestern to handle this business in a very satisfactory way. We load only about 105,000 cars a month. That, of course, varies somewhat but not greatly. Some months it is as low as 95,000, and in other months it is 115,000. But at that we only get three loads in two months for each car, or an average of one and a half loads per month, which is 18 loads a year for each car. Now the average distance a load travels on the Northwestern is 165 miles, and it takes a little less than 15 hours of running time to cover that distance on the road, so that we have this situation: We get 18 loads a year for each car, and it takes us 25 days all told to haul those loads to the places they go. The shippers have the privilege of holding the car three times as long as it takes to haul it to its destination, and the consignee has the privilege of keeping it free of cost three times as long to unload it as it takes us to haul it. These, of course, are average figures.

If we could cut down the idle time of our cars about ten per cent, and by that I mean the time other than when they are moving on the road with a load in them, it would be just the same as the addition of 95,000 cars or 135 per cent more than we now own. And if it were done throughout the country it would be the same as adding 3,400,000 more cars. These figures are hardly believable and yet they are mathematically true.

Loading Cars to Capacity

Another astonishing fact is that if each shipper were to add one ton to each load it would be the same as adding 125,000 cars in the United States. The average load today is about 25 tons and the average capacity of a freight car is 40 tons. So that there is plenty of room for an increase of one ton. The crushed stone industry, of course, can not help much in increasing the average load for they usually load to capacity. I am not giving this illustration as a pertinent suggestion to the crushed stone industry, but merely for the purpose of showing what great benefits may be derived from the almost insignificant improvement in the daily transactions of loading and unloading, ordering and prompt dispatch of cars by each and every one interested in their movement. I feel that if every one realized what these little things amounted to in the aggregate you would see that it is worth the effort and the campaign the railroads are making.

Anything that any shipper or any railway company does to expedite the movements and increase the loading of cars not only benefits himself, but benefits every one else for the reason that it saves effort and expense which may thereupon be expended in some other direction. One of the greatest concerns of the railroads today is the preventing of wasteful movement, detention and diversion of the car supply. Our cars which we have acquired for the service of the patrons on our line get away from us and we are unable to get them back, and the cars which come to us from somewhere else are not suited to our loading.

Use of Coal Cars

The coal cars of the Northwestern are suitable for handling all kinds of commodities that may be loaded in them which would not be injured by exposure to the weather. The tendency of late years has been to have a special type of hopper-bottom coal car, and when these cars get upon our road all we can do with them is to get the coal unloaded and move the cars back empty. We can not very well use such a car for other purposes. If we let our cars get off the line we have nothing left for supplying the crushed stone and gravel industry. It would appear a great waste if we were to supply one kind of car for the coal business and another kind for the crushed stone and gravel business; that would practically mean two sets of cars, one of which would be used largely in the summer-time only and the other would be used when the coal was moving in sufficient volume. Last year if there had been no strike in the coal mines there would be no shortage of cars in this territory at least with the crushed stone and gravel industry. During the time of the strike we had a surplus of gondolas and we had no call from connecting railroads or the Interstate Commerce Commission or anybody else to help out with the car supply, but as soon as the strike was over there was a great rush to move the coal.

It was necessary, of course, that there should be the maximum movement possible in the time left to get in the winter supply. We, of course, had to see to our own coal supply. Normally we have about 8000 cars handling company coal, and after a strike such as we went through it is necessary to have even more, and as a result it was very difficult to find any cars that could be used to supply our stone and gravel shippers. We tried once or twice the temporary expedience of getting together a train load or so of empty cars on Sunday and moving them specially to some particular locality, on a day when other business was comparatively light; but this, of course, got us into trouble because we were not able to do it for everybody and those who didn't get cars immediately felt that their competitors were being favored. It was then necessary to adopt arbitrary restrictions based on the car supply and the ability to handle the loads without regard to the shipper's needs. If we hadn't done this we couldn't have furnished any cars at all much of the time.

More Cars Not the Only Need

Some people have the impression if we could only get more cars the situation would be remedied, but this is not true. The possibility of handling the cars, which is controlled by the capacities of various operating facilities including locomotives, terminal yards, industrial team tracks, has a more important bearing on the subject than the number of cars. It does no good to have more cars than can be handled any more than it would to have more wagons than we have teams or drivers for. We can render better service with fewer cars (and move them more expeditiously) than we can render with a greater number of cars handled more slowly. In other words, we have found that with 85,000 or 90,000 cars on the Northwestern we have no room to turn around and everything gets blocked, whereas if we have from 60,000 to 70,000 only of the right kind of cars, we can supply everybody without any difficulty. Our biggest difficulty last year was to get rid of the cars we had received with coal from foreign lines after they were unloaded. There is always a great deal of pressure behind each individual loaded car to get it moved, but there is no pressure behind any individual empty car. Somewhere there is a load waiting for it, but it is generally a long ways off.

It is up to the railroads, of course, to attend to this phase of the transportation problem, but the shippers could help to an appreciable extent by giving the companies as much notice as possible of the movement they propose to make so the roads could attempt to furnish cars of the kind which would be most likely to get a load back when they are unloaded at their destination.

Notwithstanding this the railroads during the past year have done an enormous amount of business. Reports show that the volume of traffic moved is nearly as great as any previous time, and there seems to be no visible letup. The loading in the last week of December, records indicate, was the heaviest for this time of the year on record. It was something like 20 per cent greater than '21, and 10 per cent greater than 1920.

Now there is no foundation for the thought that the railroads are broken down, but it is admitted that they are not handling satisfactorily and expeditiously all the traffic that is offered. This is because they have not been progressing with their developments in recent years at as rapid a rate as developments of the country generally.

All that we need in this country today to bring about a rapid growth in railroad facilities is a settled policy of letting the railroads be self-sustaining. The railroads ought to be taken out of politics. It used to be the fashion to criticize the railroads because they were said to be in politics of their own accord. All we can say now is that they are kept in politics despite their desire to get out.

The Future—The Labor Problem

That covers briefly the question of cars and transportation for the shippers' needs. Now I was asked by the chairman of your program committee to say something about our thought of the future, our thought of the business for this year. I am very op-

timistic. I think everything points towards a continued increase in business. There is nothing in our own affairs that will prevent a very large business in 1923, and you can notice from the papers that the railroads are preparing for it very generally by ordering new equipment, new cars, locomotives and everything for their transportation needs. In fact our road has laid out a larger program for additions, betterments and improvement this year than they have laid out in any single year for the past seven years. The only question I have or fear is in carrying it out that we will be short of labor, and that is going to be, I am afraid, a very critical question with us—to get the necessary labor. That is being given attention all over the United States, and the question is, what are we going to do to provide our common labor? In face of that we have restricted our immigration laws, and it is time that some thought and some study was given to it. I believe that something has got to be done.

It is idle to talk about saving the jobs for American labor. American boys will not work at manual labor; they don't have to, they have an education and can do better for themselves, and we ought not to expect them to do otherwise. Any restriction arbitrarily made or otherwise imposed upon the supply of labor can not help but be detrimental to all industries in this country. From the material point of view the more common labor we can get from the old world the better off we will be and the better off the laborer will be. Rising wages do no one any good if prices increase at a faster rate.

On the other hand, of course, we must look at the question from the standpoint of making future citizens of the immigrants. Just how to select immigrants is a difficult problem, but it seems to me that we might safely open the door wide to the people from these nations from which in the past it has been our experience that we got good, sound industrious and intelligent people, who want to come here to make homes for themselves and give their descendants a better opportunity than they could have in their own country; but as to those who come from other places and who have not the ability to readily assimilate American ideals we should make them improve their fitness before being admitted.

We also should make it our business to see that when the immigrant is here he has an opportunity and is required to learn the ideals of America and the duties and responsibilities of citizenship. American ideas and ideals are simple and easily understood and they are appealing alike to the simple-minded as well as to the highly educated. There ought to be no difficulty in inculcating these ideals into the minds of all right-minded people. The trouble is we have never made any effort to do it.

The Ballast Business

Speaking of your particular industry, crushed stone, I was asked to say something as to my opinion of railroads running their own ballast plants for furnishing crushed stone. The road I represent owns a great many stone quarries in nearly all the states it runs through and in past years when dimension stonemasonry was used so extensively upon railroads in construction work, we did run and operate our own quarries. We also went into the crushed stone business in a number of places. I built a number of crushers for the company and had supervision of them. That was some years ago when I was young. I have changed my opinion about a railroad running crushers or stone quarries. In fact I have come to the conclusion that a railroad is essentially an operating proposition, that it should keep out of anything in the manufacturing or production lines that can be done better by the private individual. I think the company should be able to do outside a great deal of work that they are now doing in their own shops if they were permitted to do so.

Our stone quarries as a business proposition, our crushers, were not a success. We have leased the majority of our quarries and have leased our crushers to private companies or individuals, and they are doing better than we did. Railroad organizations are not trained for that kind of work. They are trained for railroad operation, for the business of turning around the wheels, and they don't have the men with the proper training to run a manufacturing or productive business of that sort.

Faith in America

The toastmaster spoke of the troubles of other countries with their ideas of government and their new and untried forms that they are trying to create. While we have more or less of that in this country, while there are a great many agitators advocating untried things, untried forms of government, I have an abiding faith in the American people and in American citizenship. A nation that produced the Declaration of Independence, a nation that wrote the Constitution that we have, a work that if anything that mortal man has done was inspired that was surely inspired, I have every confidence in despite all this agitation that we are coming out right at the end.

This country was settled in the early days by people who had ideals, who believed in individualism and in the right of man to pursue his own course without the heavy hand of anyone else on him. I do not believe that it was ever more fittingly described than it was by Mrs. Hemans in her verse describing the landing of the Pilgrim Fathers. I consider that idea, that germ was the making of this country and all of its institutions, when she said of that patriotic band that landed on the rough and bleak New England shores—

"There was woman's fearless eye
Lit by her deep love's truth,
There was manhood's brow serenely high,
And the fiery heart of youth."

That is what has made this country.

"The Public Interest in the Railroads"

By C. H. Markham
President of the Illinois Central System

WE railroad men are placed in a very difficult situation because of the efforts made by a great many people in this country occupying high political places to discredit the railroads for their own purposes, to further their own political ambitions. Prejudices which were created many years ago against the railroads are used by them for the purpose of securing support for office. Moreover, a great many of them have in the back of their heads a desire to bring about conditions which would result finally in the railroads' being taken over by the government, and this time kept, instead of being turned back as they were after the war.

We railroad people are being forced to do something that all of us dislike very much to do, and that is, to refute the charges that are being made by the kind of people to whom I have referred. We must do it, however, in order to bring about an understanding of the railroad situation on the part of the people of this country. Only in that way will credit be restored to the railroads and will they be permitted earnings which will enable them, from time to time, to raise the vast sums of money that must be had if the railroad plants of the country are to keep pace with the growth and development of the country. It is rather a disagreeable thing to have to do, and yet we are compelled to do it in order that we may get the truth before the people of this country.

In discussing these questions, I do not talk so much from the standpoint of the Illinois Central System; it is a well-located railroad, it is well equipped as an all-around transportation machine, and, with all modesty, I don't mind saying that it is a fairly well-managed railroad. It is doing very well now; it did very well last year. Yet, after all, the chain is only as strong as the weakest link, and it doesn't do the Illinois Cen-

tral System very much good if conditions are such that the railroad structure of the country should fail on our hands, because after all we must stand or fall together.

The railroad business is not a business in the ordinary sense of the term. It is a service, a public service, and its well being depends not only upon the kind of service that it gives but the kind of service that the people of the country want and the kind that they are willing to pay for.

There are some three hundred billions of dollars' worth of wealth in this country, the sum of $78,000,000,000 invested in agriculture, the sum of $45,000,000,000 invested in manufacturing; but, underlying it all and supporting it, is the $20,000,000,000 that is invested in the railroad plants of this country, and without those plants it is hardly necessary to say the rest of the business would have but very little value.

Railways the Fundamental Transportation Machine

A great many people are saying that the railroads of the country will fail. Improvement of waterways is being advocated in some places for the purpose of creating transportation facilities. In the first place, all of the transportation that all of the interior waterways of this country could possibly handle wouldn't be a drop in the bucket compared with the amount that is handled by the railroads. Let me give you a concrete illustration of just what that means. In round figures our export and import business amounts to about 50,000,000 tons annually, which happens to be about the tonnage handled by the Illinois Central System last year. Fifty million tons comprise the entire export and import tonnage of the whole country (not speaking now of the tonnage of the lakes), an amount that is just about equal to the tonnage of the Illinois Central Systems alone!

The railroads of this country handled last year (1921 I am speaking of now) 1,000,314,000 tons. The Panama Canal handled only 12,000,000 tons last year. The Mississippi river, with all that you have heard about the great success of the barge lines now being operated by the government, handled 665,000 tons. The point is that, after all is said and done, no matter what other transportation agencies do, you must come back to the railroads and rely upon them for handling the great bulk of the tonnage of this country.

Now, what are the roads doing to prepare for this situation? Last year orders were placed for locomotives, freight and passenger cars by all the railroads of the country amounting to $471,000,000. Some of this equipment was delivered; the balance will be put in service in 1923. We bought more freight cars in that one year than in any year since 1912, more passenger cars than any year since 1916, and the locomotives ordered in 1922 equal the orders placed in the past three years.

The Valuation of the Railways

You hear a great deal about the valuation of the railroads, and I am not going to detain you but a few minutes longer to tell you this story. In 1913, at the instance of Senator LaFollette of Wisconsin, a state which I believe is very well represented here tonight, there was passed the Valuation Act, the purpose, as is well known, being (or the thought being) to show that the railroads of the country are overcapitalized. Behind it, however, we all believe, was the thought that as a result of this valuation a basis of

value of the railroads would be fixed millions of dollars less than the capitalization and that when the time came for the government to take the railroads over they would take them over at that depreciated figure.

In 1914, pursuant to the Valuation Act passed at the instance of Senator LaFollette, the Interstate Commerce Commission began the process of valuing the roads. There has been spent altogether since that time about $85,000,000, some $60,000,000 by the railroads and about $25,000,000 by the Interstate Commerce Commission. That work has been going on since 1914; it is very rapidly reaching completion.

Now, the Transportation Act of March, 1920, required that the Interstate Commerce Commission fix freight and passenger rates on a basis that would yield a rate of return that for two years would result in 6 per cent on the value to be found by the Commission. Using the information developed by its investigations under this Valuation Act of 1913, the Commission found a tentative value of $18,900,000,000 of the railroads of this country. That is nearly $2,000,000,000 in excess of the entire capitalization of the roads in the hands of the public. Rates were made on the basis of an expected yield of 6 per cent, but as a matter of fact the return actually realized was only about 3¾ per cent.

The very people who are responsible for the passing of the Valuation Act are aided and abetted by the men who want the railroads taken over by the government, who stand committed to what we call the Plumb Plan, a plan under which the government would take over the railroads and the employes would manage them, and the government through taxation or increased rates would pay all the bills. These leaders want the railroads taken over. I don't think the rank and file of the employes want it done. These people are now claiming that the railroads are over-valued about six or seven billions of dollars.

I want to bring this down to a concrete case to show you how idle all this agitation is. The Illinois Central System is capitalized at $388,000,000. It has 6200 miles of railroad. That means about an average of $62,500 a mile. Now when I say 6200 miles of railroad, I mean roadway; that is, a mile with eight tracks would be a mile of road. When you take all of the second, third, fourth, fifth and sixth, and in some cases the seventh and eighth tracks, you find we have in round figures 10,000 miles of railroad. If you divide that into $388,000,000, you have $38,800 a mile, but that includes 75,000 freight cars, 1800 locomotives, and 1700 passenger cars. Now a low price for those locomotives would be $30,000 apiece. They are largely new. We have been buying them very freely for the past 10 or 12 years. We are placing some contracts now for engines that will cost us about $54,000, and some engines I bought as low as $18,624 and for some I paid as high as $64,000; but put an average value of $30,000 on them. You have $75,000,000 for freight cars at $1000 apiece, you have $54,000,000 for locomotives, $25,000,000 for passenger train cars.

Let me state that over again—I want you to get it in your mind: 75,000 freight cars at $1000 apiece, $75,000,000; 1800 locomotives at $30,000 apiece, $54,000,000; 1700 passenger train cars at $15,000 apiece, in round figures, $25,000,000; that makes a total of $155,000,000. You take that from the $388,000,000, and you have left about $238,000,000 in round figures. Now that $238,000,000 is $23,800 a mile for 10,000 miles. That includes again your station buildings, your bridges, roundhouses, freight houses, terminals of all sorts, your signals and rails and ties, and everything that goes to make up a railroad with the exception of the equipment. Including a right-of-way in Chicago that some people say is worth $100,000,000, that figures down to $23,800 a mile.

Comparative Costs of Modern Highways

I saw a statement the other day showing that in our own state of Illinois 400 bids

had been presented to the governor or his representative for the building of 195 miles of highway, and the average was about $25,500 a mile. Now that excluded the cost of the old road and the right-of-way, so that the $25,500 a mile was for the new work.

Now I just want to leave this thought with you: Is it possible that the Illinois Central System is not worth per mile of track more than an average mile of highway in the state of Illinois costing about $25,500 a mile? I don't know of any better way to explain the fallacy of the claims of so many people who are making the accusation that the railroads of this country are over-valued.

The question of taxation: The Illinois Central System paid, in 1914, $3,826,000 in taxes. We paid this year for 11 months $11,536,000, and we have got something over $1,000,000 to add to that for the last month. It has been $12,500,000 this year as against $3,826,000 in 1914, and $4,353,000 in 1915 and 1916.

I merely call your attention to that matter because it has an exceedingly important bearing on the future of the railroad business, and it explains to a large degree why it is that it has been so difficult for the railroads, even with the high rates obtained, to make both ends meet, to give the people the service that they ought to have, that they are entitled to, that they need, and at the same time make enough money so that they can pay a return on the new money that they must have from time to time to take care of the continued increase in the business of the country.

Gentlemen, I have talked longer than I intended to, but this is very interesting to us railroad people, and when we do get started sometimes it is pretty hard to stop. I am under many obligations to the officers of this organization for giving me the opportunity to appear before you, and I hope that the next time you come here you will give me a longer notice than I had this time and I will be glad to make a longer talk to you.

"Mooted Questions in Highway Transport"

By Dr. William K. Hatt

Director, Advisory Board on Highway Research, Division of Engineering, National Research Council

THIS association is engaged in a very laudable effort to give the taxpayer, including the railroads, a dollar's worth of road for a dollar's worth of tax money. Yet I suppose if that were done and the road built where no traffic came upon it, that dollar would be largely wasted.

Now I want for a little while tonight to speak about some of the overhead matters in connection with road building, what is called highway transport. I want to speak about some of the difficulties that are confronting our highway commissioners charged with the duty of developing the system of highway transport in our states and perhaps some of the problems placed before the highway engineers for solution, particularly in the economics of highway transportation, highway finance and the co-ordination of highway transportation with railroad transportation.

In this dark field, special interests and untrained empiricism grapple with problems which should be raised from the plane of unintelligent discussion and controversy to a scientific plane on the basis of fact-finding surveys. It is not too much to say that there must be created a new realm of economic data upon which judgment may be based and upon which teachers in colleges may promulgate a body of sound doctrines. The collection of facts underlying highway transportation has assumed a new importance lately because of the recent widespread reaction against further progress in highway development. Farmers in the Middle West now quite generally labor under financial difficulties which we hope are only temporary and they are protesting against taxation for highway development.

Highway Costs Must Not Be Confused with General Tax Increases

Now those who are concerned with the creation of the arteries of highway transport, that are absolutely necessary to discharge the existing flow of traffic, realize that this state of mind must be changed. The savings in transportation costs which are brought about by the paving of highways, and the amount of increase in taxation chargeable to the construction of highways must be separated from general increases in taxation for state and county expenditure.

The State Highway Commission of Iowa has found out that the cost of paving a dirt road can be retired in nine years by the saving in transportation costs, in tires, gasoline, and so on, and that the highway taxes—only about 15 per cent of the total taxes—are responsible for only one-eighth of the total increase in taxation since the year 1910.

Sound policies must be taught in the financing of roads, particularly as respects the relation of bonds to current revenues. Some state commissions have been criticized for paving roads far in advance of existing traffic and neglecting the maintenance of the remainder of the system, as in the state of Pennsylvania. Others, on the contrary, have laid upon the community a heavy burden of maintenance cost, both of the road and of vehicle, to the postponement of the paving of main roads to carry heavy traffic, on which a non-paved road is unsuitable both from the standpoint of physics and of economics.

Now the aim of highway development, as I see it, is the wise selection of a system of roads which will meet the economic needs of the region, which will conform to the mechanics of the situation and which will be operated in the interest of the public.

The efforts of the highway engineer to build road surfaces has not kept pace with the growth of highway traffic, which has increased so rapidly in the United States. From 1910 to 1921 the investment in rolling stock on the highways has been three times that in the road over which these vehicles run. No other country has taken up the task of furnishing highways for so large an area, some 3,000,000 square miles. Texas alone has 262,000 square miles, while France has only 212,000 square miles.

Comparison of Highway and Railway Transportation Statistics

After many years the Pennsylvania Railroad has completed a roadbed from Chicago to New York, a distance of 900 miles, over which trains can be operated safety in 20 hours. In the state of Texas a single through highway will cover an equal distance. Unless the highway program is halted by reaction, we face an annual expenditure of nearly one billion dollars for road improvements.

Now while the expenditures for the roads seem large, when we come to consider the expenditures in conducting traffic over the road, the amount spent for the roads seems small. It has been estimated by Dr. Slosson that the annual cost of highway transportation arising from the vehicle and from the road is in the neighborhood of eight billions of dollars, of which nearly two billion dollars is in depreciation of the cars. The investment in motor vehicles in 1921 was nearly nine billion dollars, which is 47 per cent of the steam railway valuation of nearly 19 billions. The investment in roads and vehicles for highways is estimated at 20 billion dollars, outside the boundaries of cities, an amount equal to investments in the railway transportation system.

In 1921 it is estimated that the number of passengers moved one mile in motor vehicles was nearly 71,000,000,000 based on an estimate of two and a half passengers per vehicle, and an annual mileage of 3500 miles, whereas the railroad passenger mileage was 37,000,000,000. The number of tons

moved one mile by motor vehicle is estimated at 6,500,000,000. Based on a 20-ton load on a mileage of 2800 miles, the railroads moved 410,000,000,000 tons, so the movement of motor vehicles is mainly passenger movement.

Who Pays Highway Costs?

Probably the most acute controversy at the present time relates to the distribution of costs for this improved highway construction and maintenance between the so-called user and general property. The opinion has arisen that there is a special class of users of highways, of improved highways. An endeavor has been made to pay for amortized construction cost and for maintenance cost from taxes on motor vehicles relieving general property of the share. I think it is difficult to single out any one class that is especially benefited by highway facilities except perhaps it be the operators of commercial freight lines whose trucks choke our roads and which demand heavy investments per mile, or the operators of lines of passenger busses. But when properly controlled, as they will be in time, by public service commissions, even these transportation services are only agencies of the public; and this is not a new use of the highways.

It is clear, of course, that the users of improved truck lines are almost entirely operators of motor vehicles, for the 2 per cent of horse-drawn traffic on lines of heavy flow of traffic is only a small part of the total. They clog the road and they interfere with the efficient operation of the roads as a channel for vehicles. Yet in the main these motor drivers are the general public. Three and one-half million farmers own automobiles or light trucks, an equal number are dwellers in cities with incomes of less than $4000 a year. It is difficult to see that they are special beneficiaries. If the so-called users are to bear the whole burden of the cost it must be a matter of convenience rather than a matter of equity.

Now more equitable proposals are made that motor traffic shall be charged only with the cost of maintenance and the surfacing, the latter to be furnished through short-term bonds, leaving the remaining cost of structures, right-of-way, grading and drainage—about 40 per cent of the whole—to be met by general taxation and to be financed by long-term bonds. So in examining the share of the cost of state highways to be charged to motor traffic, a distinction is drawn between the several elements of the road, each of which demands a separate treatment in respect to financing.

For example, the national highway from Baltimore west was located, graded and structures provided about one hundred years ago. This investment is still intact and probably has increased in value through the consolidation of the roadbed. In the past few years this road has been made into a modern highway at a cost of from $3000 to $4000 a mile for surfacing the right-of-way. The grading and the structures may be regarded as permanent improvements and might justify bonding for a long period of time. The surface, on the contrary, is that which wears out by climate as well as by use and should, in the opinion of some, be paid for by current revenues derived from the traffic.

However, a note of warning should be sounded to those who advocate the amortization of the permanent part of the highway by long-term bonds. It must not be forgotten that building of highways is a continuing need and the government cannot

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remain solvent by borrowing, for recurring expenditures; and while this generation may pass on a permanent investment in grading and right-of-way for the enjoyment of the next generation, which might be expected to help pay for these facilities, yet the next generation will have its own highways to build and may face problems unknown to this generation.

Furthermore, we may make mistakes in locating and building our roads which we hope will serve future industrial developments and these mistakes should not be passed on to the next generation. At any rate the use of long-term bonds for the entire cost of the road, including surfacing, may result in tying up the resources of communities, particularly counties, and the payments of amortization costs of securities issued for the building of roads and surfaces which have disappeared before half the period of the amortization has elapsed.

Cost of Highway Transportation

Now roughly an attempt may be made to estimate the annual cost of highway transportation (relating to the road itself) in 1921 in the United States. The expenditure on construction outside of cities was $420,000,000, amortized over a period of 10 years; the yearly cost then may be placed at $42,000,000. There was spent also $180,000,000 for maintenance and about $100,000,000 as fixed charges on outstanding road securities, so we have an annual transportation cost arising from the roadway alone as $322,000,000, or about 1 cent per person in the United States, a small amount compared with the expense of the seven or eight billions of dollars arising from the vehicles. So the money we put in roads is a mere bagatelle compared to the cost of conducting the transportation.

Now what revenue was secured from these vehicles? We had from the federal excise tax $115,000,000; state license, $125,000,000; gasoline tax, $11,000,000; municipal taxes, $11,000,000, and a personal property tax which was levied in 38 states of $75,000,000, or a total of $337,000,000 derived from the vehicles, just about the amount of the expense of the roads. However, it must be admitted that the estimates of costs are uncertain. It may be said also that our roads are not properly maintained and if the roads were brought to the surface demanded of them by the motor vehicles, much larger sums would have to be spent.

Opinions seem to differ towards the gasoline tax as the best measure of the use of the highway. If such a tax provision must be made, it should eliminate gasoline for farm purposes and tractor and motor boat transportation. Furthermore, neither the gasoline tax nor the license fee seems to be a dependable source of revenue to rely upon, since theoretically we may force a new form of fuel or decrease the popularity of motor car use. So it would seem that we must also have a so-called ready-to-use tax which represents the investment made for highways.

Importance of Secondary Roads

Now we are apt to forget the most important problem of secondary roads in thinking about these main arteries of transportation. Of the 2,500,000 miles of highways in the United States, some 10 per cent are expected to be primary roads, improved at a cost of seven or eight billion dollars. When commercial trucking lines are established bringing the farmer's products to the markets and furnishing a daily supply of milk in large cities, how is the passage of these vehicles from the primary roads to the secondary roads to be controlled? If we spend seven or eight billion dollars in the next 10 years to pave our main arteries, what should be the policy in financing the secondary roads? In one county in Tennessee it is estimated that the expenditure of five million dollars will be necessary to

raise each road one class higher, and the saving in transportation in that county—the products raised on the farm—is not sufficient to do that work.

Already demands are arising from those interested in the secondary roads that part of the state revenue derived from automobile licenses be spent on these secondary roads; and cities which have to provide streets for the through passage of these heavy vehicles are demanding their share of the revenue to meet this expense. Those who live in high class residential suburbs are troubled with the freight movement over their streets, which not only destroys the surface but depreciates the residential value of the property. So we have this necessity arising by passing through traffic around our cities. These problems of control of movement of traffic have hardly been attacked.

Co-ordination of Railways and Highways

I would like to say a few words about the relation of highway transportation to railway transportation, but I am very much abashed to attempt it in the presence of these gentlemen who probably know so much more about it than I do. I simply say that it is one of the grave problems with which I have recently come in contact in the New England states, and which is under examination in that region.

Another conception which has been recently advanced by the Department of Agriculture is based on the interests of the rural population, which they say is inaccessible to modern facilities for trade, professional service, hospitals, schools, amusements, and churches. Mr. Galpin advocates a system of roads radiating from all rail heads which are located at the 1320 terminal towns in the United States of from 2500 to 5000 population. Each of these terminal towns or rail heads will be connected with a system of market roads with a farm population of from 2000 to 7000.

Highway Accidents

One aspect of the maladjustment of highway traffic to which environment is growing is the number of mortalities and accidents. The annual toll is now 12,000 lives and unknown number of serious accidents. One motor vehicle in every thousand kills a man.

For securing safe travel on our highways, signals give warning at dangerous points, curves are being widened, roads relocated and grade crossings abolished. As in cities, these matters demand knowledge of the psychology of the human being and raise questions of standardization of signs and signals so that the driver passing from one state to another will not have to learn entirely a new set of signals or be confronted with a new set of arbitrary regulations. Highway operation is becoming an activity for special experts.

In our cities the solution of traffic problems has gone beyond the scope of regulation. More roads must be provided for vehicles and for pedestrians. The city planner is confronted with the decision of street locations. The passing of traffic through the intersections by the stop and start method or the rotary method involves problems of mechanics that have received little study. The parking and arranging of vehicles in downtown streets points to unreasonable use of valuable city property and diminishes the proper use of the automobile and the transaction of the individual business. A continuous use of private motor cars passing over our streets with only one seat in five occupied very often suggests an inquiry into the economics of such transportation in our cities. The wiping out of street railway investments through the operation of jitneys is a parallel problem with that between the commercial motor vehicle and the interurban electric railways.

Now I don't want to accentuate too unduly the troubles arising from motor traffic, or to forget the other side pictured by hundreds of cars by which the workman obtains individual transportation between his suburban home and his place of employment, nor the weaving together of the city and the country, the transportation of the formerly isolated farmer to his clubs for discussion of his problems with his fellows, and the concentration of advanced instruction in consolidated schools. In discussing maladjustments we are apt to forget specific benefits and the necessary progress of important movements.

State Highway Policies

I suppose our states have chiefly under discussion at the present time policies in highway development. In one state high class roads are built once for all in sections of the state system with the possible neglect of the maintenance of the remaining roads before they are paved. In North Carolina, on the other hand, we find wide roads well located, adequately graded and drained, and the earth surface maintained through frequent dragging by well designed maintenance organizations. In this state advantage is taken of the presence of the top soil remaining from old cultivated fields from which the excess clay has been leached by the weather, leaving a mixture of coarse sand and binding clay for road surfacing. One can travel all day long in the state of North Carolina at the maximum legal speed or over in comfort and safety on roads that cost $4000 a mile to surface and $300 a mile per year to maintain. Such roadbeds become improved and consolidated through use. An excellent foundation is secured when the traffic is developed to a point where it is no longer economical to maintain these surfaces.

Traffic Surveys

Our states are also backward in basic traffic surveys for the allocation of construction and maintenance funds must depend upon the basic survey of the flow of traffic. These demand not a measurement for a few days, for a selected period, but a basic survey throughout the year which will take into account the variations during the week, the month and the year. The laws of the increase of traffic on a road once improved and the dispersion of such traffic to other roads must be determined. In other words, the engineer of highways must be in the same position as the engineer of a city plan for the development of a system of water piping or of sewers. He must look ahead to the growth of population.

Now we have such research work in Connecticut where the movement of commodities is studied over the highways as to classification, distance, length of haul. One highway truck was stopped the other day which had a load of silk moved from the factory in the afternoon and delivered in New York the next morning at the store door, and that cargo of silk was valued at $100,000. Those highways, however, are not relieving the railroads at all of the products of the mines and of the forest; it is all high-class stuff—manufactured materials.

Engineering Problems

Passing now to problems which are most distinctly of an engineering nature, three main fields of inquiry may be distinguished:

(1) *The economics of highway location.* What sum in capital cost is an engineer justified in spending in cutting down a hill or raising a valley in order to reduce a highway grade? The answer must depend upon a determination of the operating expense of such a road, involving density of traffic, gasoline consumption, depreciation and repairs of the vehicle, and the time of transit. The gasoline consumption and repairs again depend upon the resistance of the grade, the air resistance and the resistance of the surface. Data are being rapidly accumulated to determine these resistances. We are very largely ignorant of the operating expense of the vehicle.

Prof. W. E. Lay of the University of Michigan finds that paving a gravel road is in effect reducing the grade approximately to the extent of 1 per cent; that is, that the operating expense on a 3 per cent concrete road is the same as on a 2 per cent gravel road. This difference in economic grade is a measure of the saving in capital cost of cuts and fills in highway location.

(2) *How strong a surface is necessary to carry a specified load over a determined subgrade?* This problem involves the measurement of the static and impact forces delivered by the vehicle on the road surface, the stress and strain produced in stiff slabs by concentrated loads, and the distribution of the forces over the subgrade, as well as the supporting power of the latter. We are coming rather near to the solution of the mechanics of this particular problem, and to an accurate knowledge of the properties of subgrade soils and the means of increasing their capacity to support loads by mechanical and chemical treatment.

A parallel problem asked of the automo-

tive engineer for solution is the redesigning of the vehicle so it may carry a desired load with the least demand upon the road. The larger problem of the design of the motive power of the vehicle as affected by change in highway improvements can only be suggested. It is realized that motor vehicles are not economical from the standpoint of thermodynamics, and subject to great depreciation, and too heavily powered for the level roads.

(3) *What type of road will produce transportation at least cost for the traffic in sight, or to be expected in the near future?* This, of course, depends not only on the traffic, but on the supply of road materials. In Illinois, where gravel and broken stone must be shipped in at heavy transportation charges, it is economical to haul enough cement to bind together these materials into a concrete road. In Indiana, where there are abundant supplies of good gravel alongside the road, the solution is different. There the problem is to determine the intensity of traffic at which it no longer becomes economical to maintain a gravel road, which should then give place to a paved road. We know the capital costs of construction, and have some idea of the yearly cost of maintenance of the road, but we have but little reliable data upon the differences in operating expense between a gravel road and a paved road in the form of tire renewal, gasoline consumption, repairs, painting, time, etc. We do know, however, that on a main traveled road carrying a yearly average of 300 or 400 vehicles a day, the saving in such operating costs will, within a period of seven or eight years, entirely retire the difference in capital cost as between the second-class road and the paved road, independent of the saving in cost of the grading of hills due to steeper grades, due to paved roads. It is the engineer's duty to lay the facts before those on whose votes will depend policies for the paving of roads.

In certain areas of the country such as Arizona, where it is difficult to obtain water, and where no heavy traffic need be expected, types of roads with a crushed-stone base and bituminous top suggest themselves. There is no nostrum to be used for all cases.

Small differentials become increasingly important as the traffic grows in volume and changes in character, and much attention is now being paid to the perfection of the surface of all classes of roads.

From Maine to California and from Florida to New Hampshire, second-class roads such as gravel are being deformed under motor traffic with rhythmic corrugations. The origin of these, and the laws governing their growth and distribution, need investigation, as well as the method for preventing them or treating the road once they appear.

All of these are engineering problems to be solved by definite processes upon the basis of scientifically determined information, with politics and special interests excluded from council.

Research

I see no hope for the early solution and adjustment of our highway difficulties except through a co-ordinated plan of national research to establish a scientific basis of facts on which to base conclusions with respect to policies in highway development, construction, maintenance and operation. The Advisory Board on Highway Research of the National Research Council is making progress along this line. There is a large expenditure for highway research on the part of individual states, universities and federal departments. In the matter of the mechanics of concrete slabs alone, the expenditure has reached over a half million dollars. There are nearly 500 separate and distinct projects in the various fields of economics, maintenance, design of road and materials of construction carried on by individuals who are largely without intercommunication. It is the purpose of the Advisory Board to mobilize the research agencies of this country and to so co-ordinate their activities that information will be available which will enable an individual state with a hundred million dollar bond issue to spend, to spread this expenditure over lengths of time and for classes of roads to serve the transportation needs of the people of the state.

"Hands Across the Border"

By S. L. Squire

Official Representative of the Canadian Good Roads Congress

I AM a representative of the Canadian Good Roads Association, and I am proud indeed tonight to have an opportunity to say a word, not particularly for that association, but for the country which I come from.

I might say that it almost seems to me that it has become a habit with me that I am attending your convention, for this is not the first convention that I have had the opportunity of meeting with you. I want to congratulate you now, Mr. President and your officers, upon the splendid progress which is so easy to note, and while I am satisfied that that is reflected in the manner in this convention, in this banquet, in the manner by which your business is being done, I fancy that there must be some reason for it all, and I would say that that reason is the better understanding which now exists between men who are interested in work such as your own.

However, in listening to the addresses yesterday and listening to your chairman tonight, I have learned that your association represents a national work, a work of national scope, and extends from the Atlantic seaboard to the shores of the Pacific.

S. L. Squire

When I am speaking, sir, from the standpoint of a Good Roads Association, I can take in even more scope than that, for I believe that we can take in the civilized world, for we find that wherever civilization is there is an interest in highways. However, there was one address given yesterday which I found considerable food for thought. A banker appeared before you, for it seems that it is necessary for even stone men to sometimes consult their banker, and this banker gave three great reasons which were fundamental in the granting of credit to you as being, first your quarry, second your management, and third your market.

While I feel as a representative of a Good Roads Association that the reports dealing with the production of stone during the past year gives you credit for having a very successful year, we find that the success with the stone men during the past year has not been because of industrial development or because of the expenditure of large sums of money upon great public works other than highways, that the increase in the output of your quarries has

been because of roads, and I find that in order to have this continued it requires propaganda and that is part of the work which is conducted by an association such as the Canadian Good Roads Association.

In listening to the splendid addresses which I have heard tonight, I felt very much at home, for I feel that the problems which you have here are the problems which we have across the line, and I find that the ideals which are expressed by your speakers are to a great degree the ideals which we also have, and while I look upon a map and find that there is a mark very plainly shown which divides this continent of North America, I find that is a line upon the map and that line does not exist as dividing us in our ideals or in dividing us in the matter of our work.

We are your nearest neighbor, and when I think of that I am aware that Mexico to the south of you is also your neighbor. We are your best customer, and yet I think of the Payne-Aldridge tariff and the way you tried to penalize us; still we go on buying from you and trading with you and contributing to your profit. Yes and there are other ways that you penalize us. You have during the past several years taken a premium from our dollar ond made us pay to the tune of 17 or 18 per cent. But I want to tell you that this last year we have had the satisfaction of seeing that dollar in Wall Street, New York, not only reach par but purchased at a premium and today the Canadian dollar looks the world in the face and says with assurance, "I know that my redeemer liveth."

There is a reason for this, and I wonder if you have thought of the reasons for it. I am not going to tell you of the great resources that we have in the Dominion of Canada today, but I am going to try and take a note from the book of the secretary of your association who says that when he was a school teacher he used to try to place before the class some substance in such concrete manner that the class would be able to tell him the things that he had been teaching them. I am only going to refer to two or three things as to why the Canadian dollar today is worth what it is.

In British Columbia, one of the provinces of our Dominion, if the lumber in that country, in that province, was sawed into 2 in. planks and those planks were 16 ft. long, there would be enough lumber to make a sidewalk which would circle this globe 200 times. We have pulp wood in Canada that if the cordage, which is known, was sold at a dollar and a half a cord today, we would have enough pulp wood there alone to pay our national debt, and do you think when we are backed up with resources such as this that we need ask others why our dollar is worth a hundred cents? Not at all. But I want to refer just in a moment to the manner that you have dealt with us, and the manner that you have tried to penalize us.

I have spoken on this tariff that you have placed against us. Yes and that tariff perhaps had the effect that you wanted it to have, I don't know, you are always a kindly people, and I can't attribute any act that you would do to a thought of harm necessarily, but at any rate this tariff had the effect that during the last year the port of Montreal shipped more grain, exported more grain than any other port in the continent of North America. There was grain to the tonnage (and I am taking the statement made by the president of the Illinois Central) equal to one-tenth of all the tonnage of the export and import tonnage of the United States that went from Montreal, and that was due to that tariff largely that you people placed against us.

So when you people are making these tariffs against us, when you are placing a premium upon our dollars, you are not endeavoring to harm us, but you are endeavoring to make better people out of us, and you are certainly doing it, for we feel that it is absolutely necessary that while we respect you, we honor you, we admire you, still it is necessary that we very largely work out our own destination and we must do it perhaps unaided by yourselves.

I am only going to take a minute more, and I am going to say that you men who know or ought to know Canada better, know that we have up there an area 111,000 square miles greater than the United States and Alaska, and when I think of the majesty of her mountains, when I think of the power of her rushing rivers, when I think of the wealth of her forests and her mines, when I think of the productiveness of her prairies, it seems to me that those things should thrill us with the bigness and the wonder of it all. Our prairies were the bread basket of the British nation during the great war, and it was an act of Providence, and I want to say that while we have ideals which are the same, we feel this with you, that this great North American continent should be respected and should retain those who love constitutional government, that we with you are going to make this North American continent the home of those who love liberty and freedom, and we believe that the men who have spent their blood, our fathers and our forefathers and our brothers and our sons, should not have spent their blood in vain, but that we can still retain this great North American continent as the bulwark of the freedom of the world.

"The Good Roads Show"

By James H. MacDonald

Treasurer, the American Road Builders' Association

I AM delighted to just relate a little incident that occurred at the first meeting that I attended this evening, which was with the board of directors of the American Road Builders' Association. We had a gentleman present with us who has been with you this evening. In a few well chosen words he presented his subject for our consideration, which was the subject which has been so ably treated by Professor Hatt. The result was that I had the distinguished pleasure and great honor to make a motion that $1000 be appropriated for the splendid work that he has engaged in, and also the motion carried with it another suggestion, and that was that if the treasury of the American Road Builders' Association would warrant it, we would give him another thousand. And as I sat here tonight and looked over this audience, I thought that this association, which has grown by leaps, and bounds in a very short time should be a part of and united within its membership with the American Road Builders' Association; and as the oldest member of that association, I would like to ask you to give that careful consideration by reason of the fact that our aims are your aims, our purpose in life is your purpose in life. The association that we have is with those industries with which you are so closely allied, so a perfect union would be possible, and I shall present that matter to our association, that we may think about arranging some pleasant suggestion of that kind. It is well to think it over.

The greatest meeting, the greatest show in road building in my judgment that was ever held in the history of the world, I had the pleasure of addressing this morning. By rather strange coincidence, I stood on the platform this morning within a hundred feet of where I stood on the platform during the birth of the association 20 years ago, right here in Chicago in the Auditorium. I said, "Ladies and Gentlemen," when I stood up and I turned to the stage where we had hired a band and my entire audience was practically that which was on the stage—the band.

I come in here today and I find this great state solidly identified with the road movement. I find in this city, a city so great that it has a population greater than any one of the 36 states in the Union, a great miracle of progress, $218,000,000 in buildings that have had a permit given for erec-

tion up to December 1, 1922. If placed side by side, those buildings would take in a distance of 85 miles. I find your automobiles contributed $7,000,000 for highway improvement. I find that Governor Small said that with the same amount of money and increase that has been shown during the past year, in 25 years you would have $300,000,000 contributed in fees by those who use automobiles, and that would be sufficient, he said, to pay off your entire bonded indebtedness of $60,000,000 and have enough money in the treasury to issue another $100,000,000, and that has all grown up right here in these 20 years that the American Road Builders' Association has been in existence.

Future for Macadam Roads

I think Brother Hall and several more in Ohio tried one time to steal me away from Connecticut and bring me over into Ohio because I had been so devoted to the stone business; I was known by a very large title and maybe I did not deserve being called the Macadam of America. It was not strange that I should favor macadam roads by reason of the fact in the natural transition of going from one method to the other in road construction that I should adopt the best method of construction at that time that I knew.

During the life of Roy Stone, Martin Dodge, Logan Waller Page, and Thomas H. MacDonald of the Office of Public Roads at Washington, I served through them all, and I want to say this, and I am very familiar with other pavements: It will be a long time before the sun sets on the last mile of well-built macadam roads in America.

I believe that when that great corporation that furnished so much illuminating power found that they had millions of barrels of a byproduct and ingeniously suggested it was the finest thing in the world to perpetuate the life of a macadam road, it would have paid the United States a great many hundred million dollars had they paid the cartage of that material and passed it overboard into some river, that would have carried it away never to be seen again, by reason of the fact that instead of being a helpful influence on the macadam road, it was a destructive force and burnt out all the bonding material that was in the natural waterbound macadam road, and destroyed it so as to cause the enmity that has not as yet ceased.

A well-built macadam road is a good road; it will carry the traffic, if well built and well drained, for many years to come, and with a little assistance, with the traffic that you have now, so as to make the surface smooth on the top, in my judgment it is an economic form of road construction that we will not wisely abandon for a long time to come, until something better offers itself.

Farm-to-Market Roads

My friend Upham today in a very good paper down at our meeting spoke about the splendid assistance that he is receiving in his state by his subgrade roads. We have many miles of well-built dirt roads, well-built gravel roads, well-built macadam roads, well-built cement roads and well-built bituminous roads in Connecticut. Just as long as people differ in temperament, just as long as the financial condition of the states are different, just as long as the traffic differs, you will have all kinds of roads; and while I am a firm believer in the trunk line system of continuous roads, I am not so closely wedded to the trunk line system, that I say the expense of the nearest and best access from the farm to the market place shall be abandoned.

The Report of the Nominating Committee

MR. GRAVES: The Nominating Committee, in endeavoring to make nominations for the Board of Directors, ran up against a somewhat unexpected situation. There seemed to be the impression in many of our minds, which ultimately proved to be erroneous, that the Executive Committee could be any five members appointed by the president, the three officers, however, the president and first and second vice-presidents, being *ex-officio* members. It only left him two, of course, that he could appoint. We were under the impression that those

W. H. Hoagland
First Vice-President

President

W. L. Sporborg
Second Vice-President

two need not be taken from the Board of Directors; therefore, the Nominating Committee made up a Board of Directors on that assumption. Then, we found that the Executive Committee must be drawn from the Board of Directors for the men we felt should be there. There was a very delightful spirit of modesty on the part of every director that he would be the one to drop off, and for a while it looked like we would have no Board of Directors, because everybody was getting off to make room for somebody else. We gave the matter very serious consideration and called in the Resolutions Committee and everyone else that we could get our hands on and decided unanimously to recommend to you, through the Resolutions Committee, what we believe is a wise change to the effect that the article in the constitution which states that the Board of Directors shall consist of 15 members elected at the annual convention be changed to read 19 members. And, Mr. President, in behalf of the Resolutions Committee, I move you that that amendment be made at this time.

The motion was seconded and carried.

MR. GRAVES: The Nominating Committee has spent a number of hours in the consideration of the nominations which it is its duty to make to this convention, and I mention that merely to let you know it hasn't been thoughtlessly or hastily done. We have interviewed almost every one who had any thought on the subject at all, and we have been open to suggestions of all kinds, seeking only to endeavor to get those men whom we thought would best serve the interests of this association during the ensuing year.

We regret extremely the necessity which seemed to confront us that it was not feasible to nominate against President Eames for a second term. It would have been a most pleasing nomination, not only to our committee, but we were quite sure to every man at this convention.

The Nominating Committee, Mr. President, begs leave to submit to the convention the following nominations for officers for the year 1923:

F. W. Schmidt, Morristown, N. J., president.
W. H. Hoagland, Columbus, Ohio, first vice-president.
W. L. Sporborg, Syracuse, N. Y., second vice-president.

Directors

W. Scott Eames, New Haven Trap Rock Co., New Haven, Conn.
John Rice, General Crushed Stone Co., Easton, Pa.; New York and Massachusetts.
A. J. Blair, Lake Shore Stone Co., Milwaukee, Wis.
J. J. Sloan, Wisconsin Granite Co., Chicago.
A. A. Hall, Ohio Marble Co., Piqua, Ohio.
B. D. Pierce, Jr., Connecticut Quarries Co., New Haven, Conn.
W. G. Swart, Mesabi Iron Co., Babbitt, Minn.
W. W. Boxley, W. W. Boxley & Co., Roanoke, Va.
Norman Hely, Edward Hely & Co., Cape Girardeau, Mo.
O. M. Graves, General Crushed Stone Co., Easton, Pa.; New York and Massachusetts.
A. R. Wilson, Granite Rock Co., Watsonville, Calif.
Allen Patterson, Bluffton-Lewisburg Stone Co., Lima, Ohio.
C. M. Doolittle, Canada Crushed Stone Co., Dundas, Ont., Canada.
James Savage, Buffalo Crushed Stone Co., Buffalo, N. Y.
Howard E. Blair, France Stone Co., Toledo, Ohio; Indiana and Ohio.
R. W. Scherer, Western Lime and Cement Co., Milwaukee, Wis.
J. F. Schroeder, Linwood Cement Co., Davenport, Iowa.
R. B. Tyler, R. B. Tyler Stone Co., Louisville, Ky.
Thomas McCroskey, American Limestone Co., Knoxville, Tenn.

Mr. President, the Nominating Committee offers these names for the respective offices and we move you that they be elected.

MR. PIERCE: I move that the clerk cast one ballot.

The motion was seconded and carried.

SECRETARY SANDLES: The secretary casts the unanimous vote of this convention for those officers and directors nominated.

MR. GRAVES: Mr. President, there is only one resolution which is unbeknown to you, and that is, that it seems rather paltry and trite to the Resolutions Committee to merely ask that a resolution be passed instructing the secretary to send a letter of appreciation to our now ex-president, Mr. Eames, for his services the past year, and I move you, Mr. Secretary, that we all rise and show Mr. Eames in some manner our appreciation of the most profound work I believe that this association has ever received from any single man.

The motion was seconded and the audience arose and applauded.

SECRETARY SANDLES: Now just a word, folks. Perhaps I more than anyone else am in position to testify that Mr. Eames has kept the faith the past year. He has been earnest, he has left nothing undone, he has omitted no expense of his own personal account in order to make this meeting the success it has been, and I want to say to you it is your business and your duty not only to give this vote of thanks and appreciation to President Eames, but when he gets down and you get a chance, take him by the right hand and tell him much obliged and let him know by the way you take hold you mean it. (Applause.)

PRESIDENT EAMES: Gentlemen, it certainly has been a pleasure to serve you the last year. If you recall, Mr. Krause was called to New York on account of the sudden sickness of his daughter. I was called upon unexpectedly a year ago to preside. After I got up here you kindly nominated me for your president this last year. I certainly appreciate what each and every one have done this year to make this meeting a success. It certainly has been a pleasure to see the constructive work that you have done at these meetings. The fact is, yesterday was the first time I have seen our organization go so far as they have in doing work as far-reaching for the country's good. I want to thank you all.

I would like to appoint a committee to wait upon our new president. I will appoint Mr. Graves and Mr. Hall.

Mr. Graves and Mr. Hall escorted Mr. Schmidt to the platform.

MR. EAMES: This man has served through five years and he deserves it. Every time that we have met together here or in Washington or Philadelphia he has always been at the president's shoulder, and I want to congratulate you.

SECRETARY SANDLES: I would like to say just a word. I feel that it is due you and due this man that five years ago when we met to organize, it was Mr. Schmidt who took out his pocketbook and laid the first ten-dollar bill on the table that started this institution going.

PRESIDENT SCHMIDT: Friends and Associates—I thank you for this honor Of course, it is not unexpected.

The mark set by my friend Mr. Eames is one that is going to be hard to follow, but I am going to do the best I can.

MR. GRAVES: I would like to announce the personnel of the Membership Committee which Mr. Eames requested me to fill in:

O. M. Graves, Easton, Pa., Chairman.
B. D. Pierce, New Haven, Conn.
Norman Hely, Cape Girardeau, Mo.
J. J. Sloan, Chicago.
A. R. Wilson, Watsonville, Calif.
N. C. Rockwood, Rock Products, Chicago.
E. S. Hanson, *Pit and Quarry*, Chicago.
T. I. Weston, Columbia, S. C.
R. B. Tyler, Louisville, Ky.
W. W. Boxley, Roanoke, Va.
A. A. Hall, Piqua, Ohio.
O. H. Binns, Casparis Stone Co., Kenneth, Ind.
E. C. Dodson, Texas Stone Products Co., Dallas, Texas.
H. A. Major, Chief Consolidated Mining Co., Salt Lake City, Utah.
I. W. Workman, North Jersey Quarry Co., Morristown, N. J.
Charles A. Freiberg, Buffalo Cement Co., Buffalo, N. Y.
George H. Balfe, Monon Crushed Stone Co., Monon, Ind.
A. J. Blair, Milwaukee, Wis.
W. F. Wise, Stringtown Crushed Rock Co., McAlester, Okla.

New Kentucky Limestone Producer

R. F. HILL, JR., and M. E. Posey, of Ashland, Ky., have organized the Ashland Limestone Co., and will erect at once at Carter, Ky., a 2000-ton per-day crushing plant. The Kennedy-Van-Saun Mfg. and Engineering Co. is designing and will supervise the erection of the plant. Provision is being made for a plant of ultimate capacity of 3000 tons per day. The quarry is that formerly operated by the Poplar Ballast Co. The Ashland Limestone Co. will erect a steam-electric power plant for all equipment, including drills and locomotives. W. J. Cavanagh is engineer for the Kennedy-Van Saun company on this project.

Discussion of the Changes in the Constitution

W. D. ROBINSON (Toledo Stone and Glass Sand Co., Toledo, Ohio): According to Mr. Graves' statement, it would take 188 members to equal the receipts for 1922. I would like to ask if he has figured what that would amount to.

MR. GRAVES: In answer to that, there has been some considerable discussion on that prior to the adoption of these recommendations by the two committees to which I referred, and it has been urged, and with reason, we feel, that our present membership of somewhere around 100 to 125 members is entirely out of proportion to that membership which we should enjoy, and in specific answer, sir, to your question, if we receive only $50 from the 100 members which we now have, it would be inadequate, obviously. It is believed, however, that this change in the membership dues will greatly facilitate the obtaining of new members. That is an objection which we have all met, no doubt yourself included, in trying to get new members. It is becoming more apparent to us what a national association can really do for the benefit of the institute as a whole and that we will have sufficient revenue, not only because our membership will so increase but because of the privilege which is extended in this change of the constitution to permit any firm to hold as many individual memberships as it pleases.

Now there are some members here at present representing anywhere from five to twelve members. We believe those firms will hold from five to twelve individual memberships and their dues will run anywhere from $100 to $300. Now there is no obligation on them other than that they have two individual memberships; we believe that a great number will take out anywhere from two to ten.

We couldn't mathematically figure out just what we would get. We feel entirely dissatisfied with the way we are going now; we had a deficit this year and it is a question of making up last year's deficit, and this scheme, while it doesn't carry with it the guarantee, seems to hold out a greater opportunity and one which is so apparent that we can make the suggestion it rather arouses our enthusiasm.

MR. ROBINSON: Wouldn't it be a good suggestion to lay aside the actual amount of these dues until the last day of our convention, when we will know what our plans are for the coming year and can make some approximation at least on the amount of money we are going to spend? It seems to me if we tie ourselves down now to really the good-will of the members as to the amount of their assessment, that you are going to have a deficit to meet before we start the year.

F. W. SCHMIDT (North Jersey Quarry Co., Morristown, N. J.): Mr. President, the question of dues was gone into last night by the members of these various committees for a space of a couple of hours and this is the result of that discussion. We can only find out by experience. As a matter of fact, the Board of Directors will decide what the expenditures shall be within the limit of the dues received, and the plan that is set forth by Mr. Graves seems to be the plan that ought to go through for a trial, at least. The present form is unsatisfactory. This seems to be the next best thing that can be worked out, and I move the recommendations be adopted.

A. A. HALL (Ohio Marble Co., Piqua, Ohio): I offer an amendment that the final action of this resolution be deferred for at least 24 hr. and that the secretary take a poll of the members here and see what the prospects are for raising enough funds to care for this association. (Seconded.)

MR. SCHMIDT: I will accept that on condition that each member will assume the responsibility of seeing the clerk and telling him what he will do, but the clerk can not poll it. Everybody can see the clerk very easily.

MR. HALL: I want to remark right here that the clerk has the registration, and by the clerk doing that, he can get at the report more accurately than he can by having the people walk into the room.

BRADFORD D. PIERCE, Jr. (Connecticut Quarries Co., New Haven, Conn.): Suppose that the members here take this quite seriously. It seems to a good many people this is the right way to do it, that if four or five will volunteer to step into one corner of the room and before you leave the room each man here come up and states how many memberships at $25 his organization will take, that could be done without burdening the secretary to look them up. You can give your name and the number of $25 memberships, and you can close the thing here this afternoon.

J. J. SLOAN (Wisconsin Granite Co., Chicago, Ill.): I think that some figures and statistics should be given out to enlighten those who are not thoroughly posted on the figures of an association like this. There are 2900 quarries in the United States and we have only a few over a hundred. Some do not care to report their tonnage to the association.

The main purpose of this organization is to broaden public policy and to bring the members in this association into one grand organization, and by combining effort and force, we can get necessary protection out of the absurd regulation of railroads, as reported by our friend, to advance the general interest of the members from coast to coast and from the Canadian line and upwards down to the Gulf, and if we are going to do that, we have got to have membership first, because it is membership and the force of membership that will compel a recognition of the industry.

If we are going to put it on a broad plane of inviting every producer in the country in for a pittance of $25 a year, we certainly ought to get instead of 160 members out of 2900, some 600 or 1000 in here within the next year, which will give us five times the revenue.

Think of an association with a report of tonnage bringing in a matter of a few thousand dollars a year. We could go out with a tin cup on a street corner in Chicago and get as much in a few days' time.

Let's build up our membership by this method, and with a budget and a membership behind it to support it, we can get legislation and correct the things we are complaining about and advance the interests of the association.

PRESIDENT EAMES: I concur with Mr. Sloan. Now I have been the president of this association a year. Frankly, I have written so many letters and I have been turned down with the same proposition that Mr. Sloan has presented. I know that our membership will be tremendously increased and I know before we leave here today lots of them will state just how many memberships they will take; if the organization will adopt and pass this resolution as the Resolutions Committee reports it, I think we will have no trouble.

MR. HALL: You are getting right at the point where I want to arrive.

PRESIDENT EAMES: I will make you chairman of that committee to find out and report back.

MR. HALL: I don't feel at liberty, however, to withdraw that amendment until after we have something definite. I am going to ask for a vote on the amendment.

JOHN F. SCHROEDER (Linwood Cement Co., Davenport, Iowa): It appears to me from the past dues that have been paid we have never yet been able to offer any plan of extensive action. Now we are going to elect a Board of Directors here to whom we are going to entrust the destiny of handling the money for this present year. Now it surely is obvious, according to our present plan, that we are going to at least get as much money as we have in the past, and it should be left to the discretion of the Board of Directors to determine the action of spending the amount of money that we are going to receive from time to time. It seems to me that is the duty of any Board of Directors to handle the funds in accordance with the cash received. We have not been able to carry out any extensive program in the past, so I think it would be proper to adopt the recommendation of the Resolutions Committee and get as much money as we possibly can,

and have the Board of Directors expend it according to their discretion and their wisdom.

MR. GRAVES: Personally, I think the perfectly sound thing to do is to adopt right now this change of dues without waiting to see how many members will take out individual memberships, and how many. There have been fully 25 or 30 men who have considered this question and feel with some degree of unanimity that we are going to get more money by this method of collecting dues that we will by our present plan.

We are not suggesting that this be done with the thought that we are going to get less money in total; we believe we are going to get more, and I think we believe that with reason of right. I am personally sponsoring the motion which I made to you that this be adopted now, and I do that without any thought, Mr. Hall, of trying to say, "Well, let's put it over because somebody doesn't understand it," because I know you personally do understand it. It isn't that at all. It does appeal to me personally, and I know that many others believe it is a perfectly sound method in getting more members and for raising more money, but if it is desired by the majority of you to insist on the amendment to ascertain how many individual memberships each will take out, then I say let's do it now.

Let each man get up and say how many memberships he will take; we will get it done, but when we have got it done, I am not sure we will have any better information on which to judge than we have now, although I think our individual membership is going to run very high, but I move you the motion without amendment, or if the amendment is insisted on that that vote be taken now.

SECRETARY SANDLES: Mr. Chairman, just a word or two. Five years ago in this hotel, nine men laid down $10 each to start the National Crushed Stone Association. They planted an acorn that has grown an oak, and Mr. President and Mr. Rockwood, it seems to me that this splendid meeting here ought to warm and make red the cockles in your hearts, to know that we have got this presence and this great number here, starting on time this morning. It is the first time that we have ever had the real atmosphere of business in this association. We are here today from New England, from the Pacific Coast, from Texas to Canada, we are as big as this nation is right now, and dull you are indeed who are here who can't see the outlines of this great industry and the recognition coming that this industry well deserves; as Mr. Eames and some one said last night, the problems ahead of us, the troubles ahead of us, are greater than the troubles we have had in the past.

Last night there met in a room upstairs of this hotel some 30 men; more earnest men never got together. They thrashed out this all-important question of finances, and after deliberation and exchange of ideas in which some of them became very earnest, this plan was agreed upon—$25 membership, that is, the unit, each corporation to take out at least two memberships.

Folks, this plan will not commit your association, will not expose it to any prosecution under anti-trust laws or anything of the kind. This plan is safety first for this association. Don't have any fear about funds not coming in. Already enough men in this industry have said that this program shall go across, and before we get through with this convention there will be a program outlined, and I believe adopted, that will make you glad you are in the stone industry.

I believe that this plan of collecting membership is a splendid one. It is going to bring the men within the fold who are engaged in this business who have vision enough to know that there are problems that should be taken care of in a national way, and I believe, my friends, that you take no chances and no risk in putting across these recommendations or amendments to your constitution, because they have thoroughly canvassed this situation and they know that the revenue will come across.

I suggest that everybody stand up here who will agree to take out one membership, that you do it now, and then those who will take out two memberships remain standing and then on up as far as you want to go.

MR. HALL: I will withdraw my amendment on condition you will carry that out.

PRESIDENT EAMES: Is Mr. Whelan here? I would like to have him speak on this.

G. J. WHELAN (vice-president and general manager, Kelley Island Lime and Transport Co., Cleveland, Ohio): I have listened very closely to this discussion and I am very heartily in favor of the amendments as proposed by Mr. Graves. It would seem to me that the objections to the other plan have been very well covered, and one is that there is a hesitancy on the part of the producer to give his tonnage. The thought has occurred to me that it might be a little unfair to the small producer, the fee being exactly the same, but the fee is so little that it doesn't seem to me there would be any objection on the part of any of the producers. I will say for the Kelley Island Lime and Transport Co. that we are very heartily in favor of the amendments as proposed.

PRESIDENT EAMES: Now all those who will take out one membership stand up (52). How many will take out two memberships? (33) How many will take out three? (22) How many will take out four? (16) How many will take out five or more? (12).

MR. HALL: I am going to ask the clerk to deduct those from the original amount and figure out and give us what we have.

Pennsylvania Welcomes Agstone Producers

THE reception of the agstone producers at their general conference in Harrisburg on March 6 was most hearty and enthusiastic. Governor Gifford Pinchot, President John M. Thomas of the Pennsylvania State College; W. C. Byers, Agricultural Bureau Director of the Pennsylvania State Chamber of Commerce; Lieutenant-Governor Davis; Professor White, the soil expert of the State College; W. H. Hill, agricultural agent of the New York Central Lines—all aided in making this Harrisburg meeting a great success by their desire to co-operate to the full in placing agricultural limestone in its rightful position.

Dr. Alva Agee, New Jersey's state secretary of agriculture, expressed his regrets because of his inability to attend the meeting.

He wrote: "I should enjoy meeting with you and those interested in promoting the use of limestone on land. The greater part of all the farm land lying between the Mississippi and the Atlantic seaboard has its productive power limited by lack of lime in the soil. Our soil experts have given us definite knowledge on that point. I have attended two meetings in Harrisburg thus far this year and must bear in mind that my work is rightly in New Jersey."

The meeting throughout was manifest with enthusiasm for the work thus far accomplished and a firm purpose to make great progress in the near future. In its March 24 issue ROCK PRODUCTS will tell more of the proceedings of this meeting. At this time, however, the magazine is going to press and the pages are almost wholly devoted to its purpose to make this issue a Quarry Manual, even at the expense of its character as a rock products newspaper.

A Tribute to Harry Seaman

THE recent death of Harry J. Seaman of the Atlas Portland Cement Co. marks the passing of a leader and a pioneer in the cement industry. During the 22 years he was at the helm of the Atlas, the company grew from a small plant of seven kilns to a huge organization operating 103 kilns with an output of 50,000 bbl. a day. Mr. Seaman gave a high type of service to his company, to the industry and to the public, says *Chemical and Metallurgical Engineering*.

To the Crushed Stone Industry of America!

THE NATIONAL CRUSHED STONE ASSOCIATION was informally organized by a relatively small group of producers meeting in Chicago in 1918. The first annual convention was held the following year in Buffalo and conventions have been held once each year since that time, in Louisville, Toronto, and in Chicago in 1922 and 1923.

Purposes of Our Association

The purpose of the association is fundamentally to study and endeavor to solve all problems affecting the crushed-stone industry, whether of an operating nature or dealing with freight rates, transportation, or national legislation. We have carefully and studiously avoided, both in spirit and in letter, either formally or informally, any reference, implied or otherwise, which would in the least tend toward developing any sort of a combination in restraint of trade. We have nothing to do with and do not discuss selling prices, nor do we submit past quotations in any shape, manner or form. We stress this thought only that you may be fully aware and assured that we have gone to an extreme in this regard in order to be well within the requirements of the Department of Justice, and have nothing to do with those forms of activity which have in some cases caused investigations of various trade associations.

The association is truly national in scope and has members from all sections of the Union — New England, Middle Eastern States, Southern Eastern States, Texas, Middle West as far west as California, and north into Minnesota, and it is noteworthy that men from all these sections assemble at our annual conventions because of the profit and pleasure to be derived.

Advantages of Membership

There are certain outstanding advantages to be derived by membership in our association, which we here call to your attention.

1. The value of personally knowing a great number of crushed-stone producers cannot be overemphasized. Personal friendships are formed which are profitable and pleasant and one comes to realize as in no other way the high character of numerous men engaged in crushed-stone production and gains a pride in his work and a realization of its importance which he would otherwise, perhaps, fail to fully develop. Friendships and respect are awakened for others engaged in this industry which does much to increase the real pleasure of our work.

2. Our annual conventions are most interesting and instructive, and if the association did nothing other than to hold these conventions it would be well worth while. They last for three days and the time is filled to overcrowding with talks by eminent men, both from within and outside of our industry, relating to all phases of our work. The opportunities afforded at these conventions of making new friends and renewing old friendships, the informal discussions that arise, the ideas that one picks up, all tend to make these annual meetings so valuable that no stone producer can afford to be absent.

3. We must ourselves recognize the importance of our industry if we are to convince others that we are worthy of their consideration. If this industry is sufficiently worth while to have its opinions as to legislative bills, priority orders, freight rates, distribution of open-top equipment, and other matters of general importance to the industry, listened to with attention and respect, it is incumbent upon us to have a functioning national body representing the majority opinion of producers. We can then state our point of view or request much more emphatically and with greater assurance of success than would be the case if we had no national organization and each producer acted as an individual unit, without reference to anyone else. Through our Standing Committee on Immigration and Railroads we are able to present to the I. C. C. our transportation difficulties, when occasion arises, more forcefully and effectively than we believe could be done by an individual producer.

4. The association during the past several years, through its officers and committees, has accomplished various measures for the benefit of the entire industry. In the latter part of 1922, for instance, when open-top equipment was extremely scarce and priority orders as the movement of such equipment were in force, officers of our association went to Washington and obtained relief to the extent of obtaining such modification of the I. C. C. order as would permit the use of open-top equipment returning to the mines. A committee acting in New York state the latter part of this past year, in conjunction with the carriers, were successful in preventing a 15 per cent increase in intrastate movements, although the rate was increased somewhat, and secured a substantial reduction in interstate movements originating in New York. A committee recently visited Washington and appeared for some little while before the House and Senate Committees on Immigration in an endeavor to secure congressional action which would, while still wisely restricting immigration, permit a sufficient amount of labor from Southeastern Europe to enter this country annually as would insure us a reasonable supply of labor of this sort. Other incidents could be cited, but these serve to illustrate some of the things in which our organization is interested and endeavoring to guide along safe and sound lines.

5. We believe that we are just on the threshold of the service which a national organization can render to its members. There is now in process of formation a research board, employing a high-calibred, skilled research engineer, to develop to the full all the uses to which crushed stone in its various forms can be put, in an endeavor to develop and create new markets and to disseminate to the members useful information bearing upon all phases of production problems. Questions of national importance to the industry are constantly arising and it is the purpose of our association to have active committees studying every phase of each problem presented in order to safeguard our interests.

We do not propose at any time to urge the passage or defeat of any measure to a Public Service Commission, public carrier, Interstate Commerce Commission or legislative body which is inconsistent with the best interests of the nation as a whole, but we recognize the danger of our heretofore relatively unorganized industry being overlooked and avoidable hardships being worked upon it, because of a lack of knowledge of its needs and requirements or a full conception of its basic importance.

6. Even though you have not been a member of this association, you have been enjoying, doubtless, some of the benefits which have accrued from our efforts, particularly with regard to open-top equipment, freight rates, and legislative action, and we feel that you will recognize a responsibility resting upon you to join the association in order that you may bear your share of the financial expense and contribute your presence and counsel at our meetings.

Membership Dues

You will note from the accompanying membership blank that an individual membership is $25 a year, payable in advance, and that firms and corporations are expected to take out at least two such memberships and as many more as they may desire. A great many of our members have a number of individual memberships in order that various ones of their executives and plant superintendents and foremen may be present at the annual conventions and profit by the experience, and also thereby contribute annually a sum of money somewhat more in proportion to the benefits to be derived from membership in this association. However, it is to be distinctly understood that in the case of a firm or corporation two memberships, at $25 each, constitute their full and complete financial obligation and no pressure of any sort is brought to bear on them to increase their annual payments unless they should voluntarily desire to do so.

Yours sincerely,

OTHO M. GRAVES,
Chairman, Membership Committee.

Membership Application

NATIONAL CRUSHED STONE ASSOCIATION

Headquarters, 405 Hartman Bldg., Columbus, Ohio

Date.....

Application is hereby made for.....individual memberships, at $25.00 each, in the

NATIONAL CRUSHED STONE ASSOCIATION

it being understood that this amount is the total of my financial obligation in and to the National Crushed Stone Association for the year 192....

(Signed).....

(Company)

Office Address:

.....**By** .....

NOTICE:—ACTIVE MEMBERS

(1) Individual membership in the National Crushed Stone Association is $25.00 each per annum.
(2) A firm or corporation is expected to take out not less than two memberships at $25.00 each.
(3) For each membership taken some person shall be designated to hold same. The name and address of such persons shall be given on the reverse side of this blank.

ASSOCIATE MEMBERS

(4) Associate Members shall be admitted upon payment of $50 per annum.
All dues payable in advance.

Herewith are the names and addresses of persons who are to hold memberships for our firm in the NATIONAL CRUSHED STONE ASSOCIATION:

NAME. **ADDRESS.**

1.....
2.....
3.....
4.....
5.....
6.....
7.....
8.....
9.....
10.....

The Rock Products Market

Wholesale Prices of Crushed Stone

Prices given are per ton, F. O. B., at producing plant or nearest shipping point

Crushed Limestone

City or shipping point	Screenings, ¼ inch down	½ inch and less	¾ inch and less	1½ inch and less	2½ inch and less	3 inch and larger
EASTERN:						
Blakeslee, N. Y.	1.00	1.25	1.10	1.10	1.10	.....
Buffalo, N. Y.			1.50 per net ton all sizes			
Chaumont, N. Y.	1.00	.....	1.75	1.50	1.50	1.50
Cobleskill, N. Y.	1.25	1.25	1.25	1.25	1.25	.....
Coldwater, N. Y.			1.50 per net ton all sizes			
Eastern Penna.	1.35	1.35	1.35	1.35	1.35	1.35
Munns, N. Y.	1.00	1.40	1.40	1.30	1.30	1.30
Prospect, N. Y.	.80	1.30	1.40	1.30	1.30	.....
Walford, Pa.	1.55	1.55	1.55	1.55	1.55	1.55
Watertown, N. Y.	1.00	.....	1.50	1.25	1.25	1.25
Western New York	.75	1.20	1.20	1.20	1.20	1.20
CENTRAL:						
Alton, Ill.	.....	.....	1.50	.....	.....	.....
Buffalo, Iowa	.90	.....	1.35	1.15	1.20	1.20
Chasco, Ill.	1.30	1.25	1.25	1.25	1.20	.....
Chicago, Ill.	1.30	1.70	1.30	1.30	1.30	1.30
Dundas, Ont.	1.00	1.35	1.35	1.25	1.10	1.10
Greencastle, Ind.	1.25	1.10	1.00	.90	.90	.90
Krause, Columbia and Valmeyer, Ill.	1.00@1.30	1.00@1.30	1.00@1.30	1.00@1.30	1.00@1.30	1.30@1.50
Lannon, Wis.	.85	.....	1.05	.95	.95	.95
Mitchell, Ind.	.80	.80	.80	.80	.80	.80
Montreal, Canada	.80	1.35	1.05	.95	.90	.....
Montrose, Iowa	.....	1.50	1.60	1.55	1.45	1.40
Sheboygan, Wis.	1.10	1.10	1.10	1.10	.....	.....
Southern Illinois	1.35	1.35	1.35	1.25	1.25	.....
Stolle, Ill. (I. C. R. R.)	1.30	.....	1.35	1.35	1.35	1.35
Stone City, Iowa	.75	.....	1.50	1.40	1.35	.....
Toledo, Ohio	1.60	1.70	1.70	1.70	1.60	1.60
Toronto, Canada	1.90	2.25	2.25	2.25	2.00	2.00
			Prices include 90c freight			
Waukesha, Wis.	1.00	1.00	1.00	1.00	1.00	1.00
SOUTHERN:						
Alderson, W. Va.	.75	1.25	1.40	1.25	1.15	.....
Bridgeport, Texas	1.25	1.25	1.40	1.40	1.40	1.25
Bromide, Okla.	.75	2.00	1.75	1.60	1.50	1.25
Cartersville, Ga.	.....	1.50	1.50	1.10	1.10	.....
Chickamauga, Tenn.	.75@1.00	.90@1.25	.....	.75@1.00	.75@1.00	.....
El Paso, Texas	1.00	1.00	1.00	1.00	1.00	.....
Ft. Springs, W. Va.	.60	1.15	1.40	1.35	1.20	.....
Garnet and Tulsa, Okla.	.50	1.60	1.60	1.45	1.45	.....
Ladds, Ga.	.....	.....	1.40	1.40	1.40	.....
Morris Spur (near Dallas), Tex.	1.25	1.25	1.40	1.40	1.40	1.25
WESTERN:						
Atchison, Kans.	.50	1.80	1.80	1.80	1.80	1.80
Blue Spr'gs and Wymore, Neb.	.20	1.55	1.55	1.45	1.35	1.30
Cape Girardeau, Mo.	1.35	.....	1.10	1.35	1.10	.....
Kansas City, Mo.	1.00	1.50	1.50	1.50	1.50	1.50

Crushed Trap Rock

City or shipping point	Screenings, ¼ inch down	½ inch and less	¾ inch and less	1½ inch and less	2½ inch and less	3 inch and larger
Branford, Conn.	.60	1.50	1.30	1.10	1.00	.....
Bound Brook, N. J.	1.80	2.30	1.90	1.50	1.40	.....
Dresser Jct., Wis.	1.00	2.25	.....	1.75	2.00	.....
Duluth, Minn.	.90@1.00	2.25	1.75@2.00	1.35	1.35	1.35
E. Summit, N. J.	2.30	2.50	2.20	1.90	1.60	.....
Eastern Massachusetts	.60	1.85	1.40	1.40	1.40	1.40
Eastern New York	.75	1.50	1.30	1.30	1.40	1.40
Eastern Pennsylvania	1.25	1.70	1.60	1.50	1.40	1.40
New Britain, Middlefield, Rocky Hill, Meriden, Conn.	.60	1.35@1.45	1.15@1.25	1.05	.95@1.00	.....
Oakland, Calif.	1.75	1.75	1.75	1.75	1.75	.....
Richmond, Calif.	.50*	.....	1.50*	1.50*	1.50*	.....
Spring Valley, Calif.	.70	1.55	1.50	1.40	1.35	1.35
Springfield, N. J.	2.00	2.20	2.00	1.80	1.75	1.75
Westfield, Mass.	.60	1.35	1.25	1.10	1.00	.....

Miscellaneous Crushed Stone

City or shipping point	Screenings, ¼ inch down	½ inch and less	¾ inch and less	1½ inch and less	2½ inch and less	3 inch and larger
Buffalo, N. Y.—Granite	.90	.....	1.20	1.00	1.05	1.10
Berlin, Utley and Red Granite, Wis.	1.60	1.70	1.60	1.50	1.40	.....
Columbia, S. C.—Granite	.50	.....	2.00@2.50	2.00	.....	1.75@2.00
Dundas, Ont.—Limestone	1.00	1.35	1.35	1.25	1.10	1.10
Eastern Penna.—Sandstone	.85	1.55	1.55	1.40	1.35	1.30
Eastern Penna.—Quartzite	1.20	1.30	1.20	1.20	1.20	1.20
Lithonia, Ga.—Granite	1.00	.....	1.50	1.25	1.00	1.00
Lohrville, Wis.—Cr. Granite	1.35	1.40	1.30	.....	1.20	.....
Middlebrook, Mo.—Granite	3.00@3.50	.....	2.00@2.25	2.00@2.25	.....	1.50
San Diego, Calif.	.50@ .70	1.45@1.75	1.40@1.70	1.30@1.60	1.25@1.55	1.25@1.55
Sioux Falls, S. D.—Granite	1.00	1.60	1.55	.....	1.50	.....

*Cubic yard. †Agrl. lime. ||R.R. ballast. §Flux. ‡Rip-rap, a 3-inch and less.

Agricultural Limestone (Pulverized)

Chaumont, N. Y. — Analysis, 95% $CaCO_3$, 1.14% $MgCO_3$ — Thru 100 mesh; sacks, 4.00; bulk	2.50
Grove City, Pa. — Analysis, 94.89% $CaCO_3$, 1.50% $MgCO_3$; 60% thru 100 mesh; 45% thru 200 mesh; sacks, 5.00; bulk	3.50
Hillsville, Pa.—Analysis, 92% $CaCO_3$, 1.67% $MgCO_3$, 75% thru 100 mesh; 100% thru 50 mesh; sacks, 5.00; bulk	3.50
Jamesville, N. Y. — Analysis, 89.25% $CaCO_3$; 5.25% $MgCO_3$; pulverized, bags, 4.00; bulk	2.50
New Castle, Pa.—89% $CaCO_3$, 1.4% $MgCO_3$—75% thru 100 mesh, 84% thru 50 mesh, 100% thru 10 mesh; sacks, 4.75; bulk	3.06
Walford, Pa.—Analysis, 50% thru 100 mesh; 4.50 in paper; bulk	3.00
Watertown, N. Y. — Analysis, 96% $CaCO_3$; .02% $MgCO_3$; 90% thru 100 mesh; bulk, 2.50; sacks	4.00
West Stockbridge, Mass., Danbury, Conn., North Pownal, Vt.—Analysis, 90% $CaCO_3$ — 50% thru 100 mesh; paper bags, 4.25—cloth, 4.75; bulk	3.00
Alton, Ill. — Analysis, 97% $CaCO_3$, 0.1% $MgCO_3$; 90% thru 100 mesh	5.00
99% thru 200 mesh	8.00
Belleville, Ont. — Analysis, 90.9% $CaCO_3$, 1.15% $MgCO_3$—45% to 50% thru 100 mesh, 61% to 70% thru 50 mesh; bulk	2.50
Chasco, Ill.—Analysis, 96.12% $CaCO_3$, 2.5% $MgCO_3$; 90% thru 100 mesh..	5.00
90% thru 50 mesh	1.35
Detroit, Mich.—Analysis, 88% $CaCO_3$, 7% $MgCO_3$—75% thru 200 mesh, 2.50@4.75—60% thru 100 mesh	1.80@3.80
Marblehead, Ohio — Analysis, 83.54% $CaCO_3$, 14.92% $MgCO_3$; 60% thru 100 mesh; 70% thru 50 mesh; 100% thru 10 mesh; sacks	4.50
Bulk	3.00
Piqua, Ohio — 70% thru 100 mesh; bags, 5.00; bulk	3.50
90% thru 100 mesh; bags, 7.00; bulk	5.50
Yellow Springs, Ohio — Analysis, 96.08% $CaCO_3$, 63% $MgCO_3$; 32% thru 100 mesh; 95.57%, sacked. 6.00; bulk	4.25
Cape Girardeau, Mo.—Analysis, 93% $CaCO_3$, 3.5% $MgCO_3$; 50% thru 100 mesh	1.50
Hot Springs, N. C.—50% thru 100 mesh; sacks, 4.25; bulk	2.70
Knoxville, Tenn.—80% thru 100 mesh	2.70
80% thru 200 mesh	3.50
(Bags 1.25 extra)	
Linville Falls, N. C.—Analysis, 57% $CaCO_3$, 39% $MgCO_3$; 50% thru 100 mesh; bulk	2.75
Mountville, Va. — Analysis, 76.60% $CaCO_3$, 22.83% $MgCO_3$—50% thru 100 mesh; 100% thru 20 mesh; sacks	5.00
Colton Calif.—Analysis, 95% $CaCO_3$, 3% $MgCO_3$—all thru 20 mesh—bulk	4.00
Lemon Cove, Calif.—Analysis, 94.8% $CaCO_3$, 0.42% $MgCO_3$; 60% thru 200 mesh; sacks, 5.25; bulk	4.50

Agricultural Limestone (Crushed)

Alton, Ill.—Analysis, 98% $CaCO_3$, 0.1% $MgCO_3$; 90% thru 50 mesh	1.50
Bellevue, Ohio — Analysis, 61.56% $CaCO_3$, 36.24% $MgCO_3$; ¼ in. to dust, about 20% thru 100 mesh	1.25
Bettendorf, Ia., and Moline, Ill.—97% $CaCO_3$, 2% $MgCO_3$; 50% thru 50 mesh; 50% thru 4 mesh	1.50
Buffalo, Ia.—90% thru 4 mesh	1.00
Cape Girardeau, Mo. — Analysis, 93% $CaCO_3$, 3.3% $MgCO_3$; 50% thru 4 mesh	1.35
90% thru 4 mesh, cu. yd.	1.35
Chicago, Ill.—Analysis, 53.63% $CaCO_3$, 37.51% $MgCO_3$; 90% thru 4 mesh	.80
Columbia, Ill., near East St. Louis—¼-in. down	1.25@1.80
Elmhurst, Ill. — Analysis, 35.73% $CaCO_3$, 20.69% $MgCO_3$ — 50% thru 50 mesh	1.25
Huntington and Bluffton, Ind.—Analysis 61.56% $CaCO_3$, 36.24% $MgCO_3$; about 20% thru 100 mesh	1.25

(Continued on next page)

Agricultural Limestone

(Continued from preceding page)

Greencastle, Ind.—**Analysis, 98% $CaCO_3$**—50% thru 50 mesh..... **2.00**
Kansas City, Mo.—50% thru 100 mesh **1.50**
Krause and Columbia, Ill.—Analysis, 90% $CaCO_3$, 90% thru 4 mesh..... **1.20**
Lannon, Wis.—Analysis, 54% $CaCO_3$, 44% $MgCO_3$; 99% thru 10 mesh; 46% thru 60 mesh..... 2.00
Screenings (¼ in. to dust)..... 1.00
Marblehead, O.—**Analysis, 83.54% $CaCO_3$**, 14.92% $MgCO_3$; screenings, 40% thru 100 mesh, 53% thru 50..... 1.25
60% thru 100 mesh, 70% thru 50 mesh, 100% thru 10 mesh; sacks, 5.00; bulk 3.50
Milltown, Ind.—Analysis 94.41% $CaCO_3$, 2.95% $MgCO_3$; 33.6% thru 100 mesh, 40% thru 50 mesh..... 1.25@1.65
Mitchell, Ind.—**Analysis, 97.65% $CaCO_3$, 1.76% $MgCO_3$, pulverized** limestone **1.50**
Montrose, Ia.—90% thru 100 mesh..... 1.25
Narlo, Ohio—Analysis 56% $CaCO_3$, 43% $MgCO_3$, limestone screenings, 37% thru 100 mesh; 55% thru 50 mesh; 100% thru 4 mesh..... 1.50@2.00
Ohio (different points), 20% thru 100 mesh; bulk ..... 1.25@1.50
River Rouge, Mich.—Analysis, 54% $CaCO_3$, 40% $MgCO_3$; bulk..... .80@1.40
Stolle, Ill., near East St. Louis on I. C. R. R.—Thru ½-in. mesh..... **1.30**
Stone City, Ia.—Analysis, 98% $CaCO_3$ 50% thru 50 mesh..... **.75**
Toledo, Ohio—¼-in. to dust, 20% thru 100 mesh 1.00
Waukesha, Wis.—No. 1 kiln dried..... 2.00
No. 2 Natural..... 1.75
Alderson, W. Virginia—Analysis 90% $CaCO_3$; 90% thru 50 mesh..... 1.75
Cape Girardeau, Mo.—Analysis, 93% $CaCO_3$, 3.5% $MgCO_3$..... 2.00
90% thru 4 mesh..... 1.50
Cartersville, Ga.—Analysis 66% $CaCO_3$, 33% $MgCO_3$—all passing 10 mesh..... 1.75
Claremont, Va.—Analysis, 92% $CaCO_3$, 2% $MgCO_3$; 90% thru 50 mesh..... **3.00**
50% thru 50 mesh; 90% thru 4 mesh; 50% thru 4 mesh..... **2.75**
Ft. Springs, W. Va.—Analysis, 90% $CaCO_3$—90% thru 50 mesh..... 1.50
Ladds, Ga.—50% thru 50 mesh..... 2.00
Garnett, Okla.—Analysis, 80% $CaCO_3$, 3% $MgCO_3$; 50% thru 50 mesh..... **.50**
Kansas City, Mo., Corrigan Sid'g—50% thru 100 mesh; bulk..... 1.80
Tulsa, Okla.—90% thru 4 mesh..... .50

Miscellaneous Sands

Silica sand is quoted washed, dried and screened unless otherwise stated.

GLASS SAND:
Berkeley Springs, W. Va..... 2.00@2.25
Cedarville and South Vineland, N. J.—Damp, 1.75; dry..... 2.25
Cheshire, Mass. (damp)..... **2.50**
Columbus, Ohio ..... 1.50@ 2.00
Dunbar, Pa. (damp)..... 2.50
Falls Creek, Pa..... 2.25
Hancock, Md.—Damp, 1.50; dry..... 2.00
Klondike and Pacific, Mo..... 2.50
Mapleton, Pa. ..... 2.25@ **2.50**
Mapleton Depot, Pa.—Damp, 2.00; dry 2.75
Massillon, Ohio 3.50
Michigan City, Ind. ..... .50@ .55
Mineral Ridge, Ohio..... 2.75
Montoursville, Pa. 2.00
Oregon, Ill. ..... 1.50@ 2.00
Ottawa, Ill. **2.50**
Pittsburgh, Pa.—Dry, 4.00; damp..... **3.00**
Rockwood, Mich. ..... 2.50@ 3.00
Round Top, Md..... **2.25**
Sands, Pa. 2.50
San Francisco, Cal..... 3.00@ **3.50**
St. Mary's, Pa. 3.00
Thayers, Pa. 2.50
Utica, Ill. **1.50**
Zanesville, Ohio ..... 2.00@ **2.50**

FOUNDRY SAND:
Albany, N. Y.—Core..... 1.25@1.75
Furnace lining ..... 2.25@2.75
Molding fine, coarse and brass molding (winter shipment)..... 2.25@2.50
Sand blast (kiln dried)..... 2.25@4.00
Allentown, Pa.—Core and molding fine 1.50@1.75
Arenzville, Ill.—Molding fine ..... 1.50@1.75
Brass molding **1.75**
Beach City, O.—Core, washed and screened ..... 2.00@2.50
Furnace lining ..... 2.50@3.00
Molding fine and coarse..... 2.25@2.50
Cheshire, Mass.—Furnace lining, molding, fine and coarse..... **5.00**
Sand blast ..... **5.00@8.00**
Stone sawing **6.00**
Cleveland, O.—Molding coarse..... 1.50@2.00
Brass molding ..... 1.50@2.00
Molding fine ..... 1.50@2.25
Core ..... **1.25@1.50**

(Continued on next page)

Wholesale Prices of Sand and Gravel

Prices given are per ton, f.o.b., at producing plant or nearest shipping point

Washed Sand and Gravel

City or shipping point	Fine Sand, 1/10 in. down	Sand, ¼ in. and less	Gravel, ½ in. and less	Gravel, 1 in. and less	Gravel, 1½ in. and less	Gravel, 2 in. and less
EASTERN:						
Ambridge and So. Heights, Pa.	1.25	1.25	1.25	.85	.85	.85
Buffalo, N. Y.	1.10	.95	.85	.85	.85	.85
Erie, Pa.		.60	.90		1.00	
Farmingdale, N. J.	.48	.48	.75	1.10	1.10	
Hartford, Conn.	.90		1.25	1.15	1.15	1.15
Leeds Junction, Me.		.50	1.75	1.35	1.35	1.25
Machias, N. Y.	.75	.75	1.25	.85	.85	.85
Pittsburgh, Pa.	1.15	1.15	1.00	.70	.70	.70
Portland, Me.		.50	1.75		1.35	1.35
Washington, D. C. (Rewashed, river)	.75	.75	1.60	1.40	1.20	1.20
CENTRAL:						
Alton, Ill.		.85				
Anson, Wis.	.50	.40				.90
Barton, Wis.	.60	.60	.70	.70	.70	.70
Beloit, Wis.		.70			.80	
Chicago, Ill.		1.75@2.23	1.75@2.43			
Cincinnati, Ohio	.70	.65	.90	.90	.90	.90
Columbus, Ohio	.75	.75@1.00	.75@1.00	.75@1.00	.75@1.00	.75@1.00
Des Moines, Iowa	.50	.50	1.60	1.60	1.60	1.60
			Unwashed ballast, .50 ton			
Earlestead (Flint), Mich.	.70		60-40 sieves, .85; pebbles, .95			
Eau Claire, Wis.	.50	.45	1.25	.95		.90
Elkhart Lake, Wis.	.70	.70			.80	.80
Ft. Dodge, Iowa		1.22		2.17		
Grand Rapids, Mich.		.50		.80		.70
Hamilton, Ohio		.90			.90	
Hawarden, Iowa		.50			1.60	
Hersey, Mich.		.40			.70	
Indianapolis, Ind.	.60	.60		1.50	.75@1.00	.75@1.00
Janesville, Wis.		.65@ .75			.65@ .75	
Mason City, Iowa	.70	.60	1.75		1.70	1.60
Mankato, Minn. (pit run)	.40	.40	.50		1.25	
Milwaukee, Wis.		1.11	1.36	1.36	1.36	1.36
Minneapolis, Minn.	.35	.35	1.25@1.35	1.25@1.35	1.25	1.25
Moline, Ill.	1.00	1.00	1.60	1.60	1.60	1.60
Riton, Wis.		.40			.60	
St. Louis, Mo., f.o.b. cars	1.20	1.45	1.65	1.45		1.45
St. Louis, Mo., deliv. on job	2.05	2.20	2.35	2.15		2.10
Summit Grove, Clinton, Ind.	.65@ .75	.60@ .75	.60@ .75	.60@ .75	.60@ .75	.60@ .75
Terre Haute, Ind.		.60	.75	.75	.75	.75
Waukesha, Wis.	.50	.50	.80	.80	.80	.80
Winona, Minn.	.40	.40	1.25	1.25	1.15	1.15
			(.05 ton discount 10 days)			
SOUTHERN:						
Atlanta, Ga.	.75	.75		.90	.90	.90
Birmingham, Ala.	1.48		all gravel 1.88			
Charleston, W. Va.	all sand 1.40		all gravel 1.50			
Estill Springs, Tenn.	1.35	1.35		1.00	.85	.65
Ft. Worth, Texas	1.50@2.00	1.50@2.00	1.50@2.00	1.50@2.00	1.50@2.00	1.50@2.00
Jackson's Lake, Ala.	.50@ .60	.50@ .60	.40@1.00	1.00	.50@1.00	.50@1.00
Knoxville, Tenn.	.75@1.00	.75@1.00		1.00@1.50	1.00@1.50	1.00@1.50
Lake Weir, Fla.		.60				
Macon, Ga.		.50@ .75				
Memphis, Tenn.	1.00	1.00	1.80	1.80	1.80	1.80
N. Martinsville, W. Va.	1.00			1.20		.80
New Orleans, La.		.50			1.00	
Roseland, La.	.50		.85	.85		
WESTERN:						
Grand Rapids, Wyo.	.50	.50	.85	.85	.80	.80
Kansas City, Mo.		(Kaw river sand, car lots, .75 per ton; Missouri river, .85)				
Los Angeles, Calif.		.70	1.20	1.20	1.10	1.10
Pueblo, Colo.	1.10*	.90*		1.50*		
San Diego, Calif.	.50@ .70	.80@1.00	1.30@1.60	1.35@1.65	1.10@1.40	1.10@1.40
San Francisco, Calif.		1.00	1.00@1.20	.85@1.00	.85@1.00	.85@1.00
Seattle, Wash.	1.00*	1.00*	1.00*	1.00*		1.00*
Spring Valley, Calif.	.70	.80	1.40	1.35	1.25	1.25

Bank Run Sand and Gravel

City or shipping point	Fine sand, 1/10 in.	Sand, ¼ in.	Gravel, ½ in.	Gravel, 1 in.	Gravel, 1½ in.	Gravel, 2 in.
Atlanta, Ga.	.30@ .40	.30@ .40				
Boonville, N. Y.	.60@ .80		.55@ .75			1.00
Cape Girardeau, Mo.			River sand, 1.00 per yd.			
Cherokee, Iowa			.80 per ton—1.20 washed			
Dudley, Ky. (crushed sand)	1.00	1.00		.90		
East Hartford, Conn.			.65 per cu. yd.			
Elkhart Lake, Wis.	.70	.50			.60	.60
Estill Springs, Tenn.						.85
Fishers, N. Y.		.50@ .65		.50@ .65		
Grand Rapids, Mich.						.50
Hamilton, Ohio			.45 per cu. yd. in pit			
Hartford, Conn.		1.00*				
Hersey, Mich.				.50		
Indianapolis, Ind.			Mixed gravel for concrete work, .65			
Lindsay, Texas				.55	.55	
Janesville, Wis.		.65			.65@ .75	
Montezuma, Ind.			Road gravel .50 per ton			
Pine Bluff, Ark.			Road gravel .50			
Rochester, N. Y.	.60@ .75	.60@ .75			.50@ .65	.50@ .65
Roseland, La.		.75				
Saginaw, Mich., f.o.b. cars		.75	1.30	1.30	1.30	1.30
St. Louis, Mo.			60% gravel, 40% sand, 1.55			
Summit Grove, Ind.	.50	.50	.50	.50	.50	.50
Waco, Texas		.80		1.50		1.30
Winona, Minn.			Clean pit run .60			
York, Pa.		.95@1.20	(Crushed rock sand)			

* Cubic yard. B Bank. L Lake. || Ballast.

Crushed Slag

City or shipping point	Roofing	¼ inch down	½ inch and less	¾ inch and less	1½ inch and less	2½ inch and less	3 inch and larger
EASTERN:							
Buffalo, N. Y.	2.35	1.35	1.35	1.35	1.35	1.35	1.35
E. Canaan, Conn.	4.00	1.00	2.50	1.35	1.25	1.15	1.15
Eastern Pennsylvania and Northern New Jersey	2.00	1.20	1.50	1.20	1.20	1.20	1.20
Easton, Pa.	2.50	.80	1.25	.90	.85	.80	.80
Erie, Pa.	2.35	1.35	1.35	1.35	1.35	1.35	1.35
Emporium, Pa.			1.35	1.35	1.35	1.35	1.35
Sharpsville and West Middlesex, Pa.	2.00	1.30	1.70	1.30	1.30	1.30	1.30
Western Pennsylvania	2.00	1.25	1.50	1.25	1.25	1.25	1.25
CENTRAL:							
Chicago, Ill.			All sizes, 1.50, F.O.B. Chicago				
Detroit, Mich.			All sizes, 1.65, F.O.B. Detroit				
Ironton, O.	2.05	1.45	1.80	1.45	1.45	1.45	1.45
Steubenville, O.	2.00	1.40	1.70	1.40	1.40	1.40	1.40
Toledo, O.	1.75	1.50	1.50	1.50	1.50	1.50	1.50
Youngstown, Dover, Hubbard, Leetonia, Struthers, O.	2.00	1.25	1.35	1.35	1.25	1.25	1.25
Steubenville, Lowellville and Canton, O.	2.00	1.35	1.60	1.35	1.35	1.35	1.35
SOUTHERN:							
Ashland, Ky.		1.55		1.55	1.55	1.55	1.55
Birmingham, Ala.	2.05	.80	1.25	1.15	1.10	.95	.85
Ensley, Ala.	2.05	.80	1.25	1.15	1.10	.95	.85
Longdale, Goshen, Glen Wilton & Low Moor, Roanoke, Va.	2.50	1.00	1.25	1.25	1.25	1.15	1.05

Lime Products (Carload Prices Per Ton F.O.B. Shipping Point)

	Finishing Hydrate	Masons' Hydrate	Agricultural Hydrate	Chemical Hydrate	Ground Burnt Lime Blk.	Ground Burnt Lime Bags	Lump Lime Blk.	Lump Lime Bbl.
EASTERN								
Adams, Mass.			7.00				2.90	
Bellefonte, Pa.		10.50§	10.50§	10.50§	9.00		8.50	1.80
Buffalo, N. Y.		12.00		12.00				
Berkley, R. I.			12.00					2.30
Cassadaga, N. Y.			Agricultural marl 7.00@10.00					
Chaumont, N. Y.					2.50	4.00		
Lime Ridge, Pa.							5.00	
West Rutland, Vt.	13.50	12.00					11.00	3.20
West Stockbridge, Mass.								2.25
Williamsport, Pa.			10.00			10.00	6.00	
York, Pa. (dealers' prices)		10.50	10.50				10.50	1.65*
Zylonite, Mass.	3.20d	2.90d	7.00					
CENTRAL:								
Cold Springs, Ohio		10.00	10.00				9.00	
Delaware, Ohio	11.50	10.00	9.50	10.50			9.00	1.60
Gibsonburg, Ohio	11.50		10.00		8.00	10.00	9.00	
Huntington, Ind.		10.00					9.00	
Luckey, Ohio	11.50	10.00	10.00					
Marblehead, Ohio		10.00					9.00	1.60
Marion, Ohio		10.00	10.00				9.00	
Mitchell, Ind.				12.00	11.00		10.00	1.60
Sheboygan, Wis.								7.50d
White Rock, Ohio	11.50				8.00	10.00		
Woodville, O. (dlrs.' price)	11.50a	10.00a	10.00a	11.00a			9.00	1.60
SOUTHERN:								
Erin, Tenn.							8.50	1.50
El Paso, Tex.							7.00	1.50
Karo, Va.							7.00	1.30
Knoxville, Tenn.	18.00	11.00@12.00		11.00@12.00	10.00	11.00	8.50	1.50
Ocala and Zuber, Fla.	13.00		12.00				12.00	1.60
Sherwood, Tenn.	12.50	11.00		8.50			8.50	1.50
Staunton, Va.					4.50	5.50	8.50	1.35
WESTERN:								
Colton, Calif.			15.00				19.70	
Kirtland, N. M.							15.00	
San Francisco, Calif.	21.00	21.00	15.00	21.00			15.00	2.15*
Tehachapi, Calif.							13.00	2.00

‡100-lb. sacks; *180-lb. net, price per barrel; †180-lb. net, non-returnable metal barrel; §Paper sacks. (a) 50-lb. paper bags; terms, 30 days net; 25c per ton or 5c per bbl. discount for cash in 10 days from date of invoice. (b) Burlap bags. (c) 200-lb. bbl. (d) 280-lb. bbl. net.

Miscellaneous Sands

(Continued from preceding page)

Delaware, N. J.—Molding fine	2.00
Molding coarse	1.90
Brass molding	2.15
Dunbar, Pa.—Traction, damp	2.50
Dundee, O.—Glass, core, sand blast, traction	2.50
Molding fine, brass molding (plus 75c for winter loading)	2.00
Molding coarse (plus 75c for winter loading)	1.75
Eau Claire, Wis.—Core	1.00@1.25
Sand blast	3.25@3.75
Falls Creek, Pa.—Molding, fine and coarse	1.75
Sand blast	2.00
Traction	1.75
Franklin, Pa.—Core	1.25@1.75
Furnace lining	2.50
Molding fine	2.00
Molding coarse	1.75
Brass molding	2.00
Greenville, Ill.—Molding coarse	1.75@2.00
Joliet, Ill.—No. 2 molding sand and loam for luting purposes; milled	.80
Bank run	.65
Kansas City, Mo.—Missouri River core	.80
Kasota, Minn.—Stone sawing	1.30@1.50
Klondike, Pacific, Gray Summit, Mo.—Molding fine and coarse	2.00
Molding fine	2.00
Mapleton, Pa.—Glass, core, furnace lining, molding fine and coarse; damp 2.00, dry	2.75
Massillon, O.—Molding fine and coarse, furnace lining, core, traction	3.00
Michigan City, Ind.—Core, traction	.40@ .45
Mineral Ridge, Ohio—Core, brass molding (green)	2.00
Furnace lining, molding fine and coarse; roofing sand, sand blast, stone sawing (green)	1.75
Traction (green)	1.85
Sand blast (dry)	2.75
Montoursville, Pa.—Core	1.75@2.25
Traction	1.40
Brass molding	2.00
New Lexington, O.—Molding fine	1.75
Molding coarse	
(.75 extra per ton for winter loading)	
Oregon, Ill.—Core	1.50@2.00
Sand blast	3.50@4.00
Stone sawing	2.00@2.50
Ottawa, Ill.—Core, molding, steel, traction, roofing sand	2.00
Brass molding	3.00
Sand blast	4.00
Stone sawing	3.50
Furnace lining, molding coarse (crude)	.85@1.00
Ottawa, Minn.—All crude silica sand	.75@1.00
Rockwood, Mich.—Core	1.90
Roofing	3.00
Sand blast	3.75
Round Top, Md.—Core, furnace lining	1.45
Traction	1.60

(All per 2000 lb.)

Miscellaneous Sands

(Continued)

Columbus, Ohio—Core	.50@1.50
Sand blast	3.50@5.00
Molding fine	2.75@3.00
Molding coarse	2.50@3.00
Brass molding	2.50@3.00
San Francisco, Cal. (Washed and dried)—Core, molding fine, roofing sand and brass molding	3.00@3.50
Direct from pit.	
Furnace lining, molding coarse, sand blast	3.60
Stone sawing, traction	2.30
Thayers, Pa.—Core and traction	2.00
Furnace lining	1.25
Molding fine and coarse	1.25
Utica, Ill.—Core	75@1.50
Furnace lining	1.00@1.50
Molding coarse	.85
Stone sawing	.85
Molding fine	.75
Utica, Pa.—Core	1.25@2.25
Molding fine and coarse, traction, brass molding	2.00
Warwick, Ohio—Core, furnace lining, molding coarse; green, 2.00; dry	2.50
Molding fine, traction, dry	2.50
Brass molding fine	2.25
Zanesville, Ohio—Core	2.25
Furnace lining	2.00
Molding fine	1.75@2.00
Molding coarse	1.50@1.75
Steel molding	1.75@2.00

Talc

Prices given are per ton f. o. b. (in carload lots only) producing plant, or nearest shipping point.

Baltimore, Md.—Crude talc	3.00
Ground talc (20-50 mesh), bags	10.00
Ground talc (150-200 mesh), bags	12.00
Cubes	50.00
Blanks (per lb.)	.07
Chatsworth, Ga.—Grinding	6.00
Ground talc (150-200 mesh); bags	12.00
Pencils and steel workers' crayons (gross)	1.50@ 2.50
Chester, Vt.—Crude talc	5.00
Ground talc (150-200 mesh), bulk	6.50@ 8.50
Emeryville, N. Y.—200-325 mesh; (double air floated), bags	14.75
Glendale, Calif.—Ground talc (150-200-mesh)	16.00@30.00
(Bags extra)	
Ground talc (50-300 mesh)	13.50@15.50
200 mesh	13.50@14.50
Hailesboro, N. Y.—Ground talc (150-250 mesh), bags	18.00
Henry, Va.—Crude talc (lump mine run) per 2000-lb. ton	2.75@ 3.50
Ground talc (20-50 mesh), bags	8.75@10.00
(150-200 mesh), bags	9.75@12.50
Los Angeles, Calif.—Ground talc (200 mesh) (includ. bags)	16.00@20.00
Mertztown, Pa.—Ground talc (20-50 mesh); bulk, 5.00; bags	6.00
(150-200 mesh); bulk, 7.00; bags	8.00
Natural Bridge, N. Y.—Ground talc (150-200 mesh) bags	12.00@13.00
Rochester and East Granville, Vt.—Ground talc (20-50 mesh), bulk	8.50@10.00
(Bags extra)	
Ground talc (150-200 mesh), bulk	10.00@22.00
(Bags extra)	
Vermont—Ground talc (20-50 mesh); bags	7.50@10.00
Ground talc (150-200 mesh); bags	8.50@15.00
Waterbury, Vt. — Ground talc (20-50 mesh), bulk	5.00
(Bags 1.00 extra)	
Ground talc (150-200 mesh), bulk	8.00@14.00
(Bags 1.00 extra)	
Pencils and steel workers' crayons, per gross	1.20@ 2.00

Rock Phosphate

Raw Rock

Per 2240-lb. Ton

Centerville, Tenn—B.P.L. 72% to 75%	6.00@8.50
B.P.L. 65%	6.00
Gordonsburg, Tenn.—B.P.L. 68%-72%	4.25@5.00
Tennessee—F. o. b. mines, long tons, unground Tenn. brown rock, 72% B. P. L.	7.00
Mt. Pleasant, Tenn.—Analysis, .65-.70% B.P.L. (2000 lb.)	6.50
Paris, Idaho.—2000 lb. mine run, B.P.L. 70%	3.25

(Continued on next page)

Roofing Slate

The following prices are per square (100 sq. ft.) for Pennsylvania Blue-Gray Roofing Slate, f. o. b. cars quarries:

Sizes	Genuine Bangor, Washington Big Bed, Franklin Big Bed	Genuine Albion	Slatington Small Bed	Genuine Bangor Ribbon
24x12	$10.20	$8.40	$8.10	$7.50
24x14	10.20	8.40	8.10	7.50
22x12	10.80	8.70	8.40	7.80
22x11	10.80	8.70	8.40	7.80
20x12	12.60	9.00	8.70	8.10
20x10	12.60	9.00	8.70	8.10
18x10	12.60	9.00	8.70	8.10
18x 9	12.60	9.00	8.70	8.10
16x10	12.60	8.70	8.40	7.80
16x 9	12.60	8.70	8.40	7.80
16x 8	12.60	8.70	8.40	7 80
18x12	12.60	9.00	8.70	8.10
16x12	12.60	8.70	8.40	7.80
14x10	11.10	8.40	8.10	7.50
14x 8	11.10	8.40	8.10	7.50
14x 7 to 12x6	9.30	8.10	7.50	7.50
	Mediums	Mediums	Mediums	Mediums
24x12	$ 8.10	$8.10	$7.20	$5.75
22x11	8.40	8.40	7.50	5.75
Other sizes	8.70	8.70	7.80	5.75

For less than carload lots of 20 squares or under, 10% additional charge will be made.

(Continued from preceding page)

Ground Rock

Wales, Tenn.—B.P.L. 70%	7.75
Per 2000-lb. Ton	
Barton, Fla. — Analysis, 50% to 65% B.P.L.	3.50@8.00
Centerville, Tenn.—B.P.L., 60-65%	5.00@6.00
B.P.L. 75% (brown rock)	12.00
Columbia, Tenn.—B.P.L. 68% to 72%	5.50
B.P.L. 65% (90% thru 200 mesh) bulk	5.50
Montpelier, Idaho — Analysis, 72% B.P.L., crushed and dried	3.75
Mt. Pleasant, Tenn.—B.P.L. 65%	5.50
Twomey, Tenn.—B.P.L. 65%	6.50

Florida Soft Phosphate

Raw Land Pebble

	Per Ton
Florida—F. o. b. mines, long ton, 68/66% B.P.L.	3.00
68% (min.)	3.25
70% (min.)	3.50
Jacksonville (Fla.) District	10.00@12.00

Ground Land Pebble

	Per Ton
Jacksonville (Fla.) District	14.00
Add 2.50 for sacks.	
Morristown, Fla.—26% phos. acid	16.00
Mt. Pleasant, Tenn.—65-70% B.P.L.	5.00@ 6.00

Fluorspar

Fluorspar — 80% and over calcium fluoride, not over 5% silica; per ton f. o. b. Illinois and Kentucky mines	20.00
Fluorspar—85% and over calcium fluoride, not over 5% silica; per ton f. o. b. Illinois and Kentucky mines	21.50

Special Aggregates

Prices are per ton f. o. b. quarry or nearest shipping point.

City or shipping point	Terrazzo	Stucco chips
Chicago, Ill.—Stucco chips, in sacks f.o.b quarries		17.50
Deerfield, Md. — Green; bulk	7.00	7.00
Easton, Pa.—Evergreen, creme green and royal green marble	10.00@16.00	16.00@18.00
Slate granules		8.00@ 9.00
Granville, N. Y. — Red slate granules		7.50
Harrisburg, Va.—Black marble, bulk		12.50
Ingomar, Ohio	10.00@12.00	10.00@25.00
Milwaukee, Wis.		16.00@30.00
New York, N. Y.—Red and yellow Verona		32.00
Middlebrook, Mo.—Red		25.00@30.00
Phillipsb'g, N. J.—Green stucco dash	20.00@22.00	16.00@20.00
Poultney, Vt.—Slate granules		7.50
Red Granite, Wis.		7.50
Sioux Falls, S. D.	7.50	7.50
Tuckahoe, N. Y.		12.00@20.00
Whitestone, Ga.—White marble chips, net ton in bulk, f.o.b., bags 12½c extra	4.50	4.50

Concrete Brick

Prices given per 1,000 brick, f. o. b. plant or nearest shipping point.

	Common	Face
Appleton, Minn.	20.00	25.00@35.00
Birmingham, Ala.	13.30	21.75
Carpenterville, N. J.	16.00	31.50@40.00
Easton, Pa.	16.00	40.00@60.00
Eugene, Ore.	25.00@26.00	50.00@75.00
Friesland, Wis.	23.00@24.00	30.00@35.00
Houston, Tex.		19.50
Omaha, Neb.	16.00	30.00@40.00
Portland, Ore. (Del'd)	21.00	45.00@60.00
Puyallup, Wash.	20.00	40.00@75.00
Rapid City, S. D.	18.00	25.00@45.00
St. Paul, Minn.	15.00	30.00@37.00
Salem, Ore.	25.00	35.00@50.00
Salt Lake City, Utah	17.00@18.00	35.00@40.00
Springfield, Ill.	18.00	20.00@25.00
Wauwatosa, Wis.	13.00@14.00	28.00@75.00
Watertown, N. Y.	18.00@20.00	32.00@35.00
Winnipeg, Can.	18.00	26.00

Sand-Lime Brick

Prices given per 1,000 brick f. o. b. plant or nearest shipping point, unless otherwise noted.

Barton, Wis.	10.50
Boston, Mass.	15.00
Buffalo, N. Y.	16.50
Dayton, Ohio	12.50@13.50
El Paso, Texas	13.00
Grand Rapids, Mich.	12.25
Lancaster, N. Y.	14.00
Michigan City, Ind.	11.00
Milwaukee, Wis. (delivered)	14.00
Minneapolis, Minn.	13.00
Plant City, Fla.	10.00
Redfield, Mass.	15.00
Rives Junction, Mich.	11.00
Saginaw, Mich.	12.00
San Antonio, Texas—Common	15.00
South Dayton, Ohio	12.50@13.50
Syracuse, N. Y (delivered at job)	18.00
f.o.b. cars	14.00
Washington, D. C.	14.50

Lime

Warehouse prices, carload lots at principal cities.

	Hydrate per Ton	
	Finishing	Common
Atlanta, Ga.	23.00	20.00
Baltimore, Md.	22.00	16.25
Cincinnati, Ohio	15.80	13.30
Chicago, Ill.	18.00	18.00
Dallas, Tex.	22.50	.....
Denver, Colo.	24.00	.....
Detroit, Mich.	19.50	17.50
Kansas City, Mo.	25.60	24.00
Minneapolis, Minn. (white)	25.50	21.00
Montreal, Que.	21.00	21.00
New Orleans, La.	.....	17.25
New York, N. Y.	16.80	13.10
Philadelphia, Pa.	15.50	14.50
St. Louis, Mo.	21.40	19.20
San Francisco, Calif.	22.00	16.00
Seattle, Wash. (paper sacks)	24.00	.....

	Lump per 180-lb. Barrel (net)	
	Finishing	Common
Atlanta, Ga.	2.25†	1.85†
Cincinnati, Ohio	.....	10.75‡
Chicago, Ill.	1.50†	1.40†
Dallas, Tex.	.....	2.50†
Denver, Colo.	.....	2.70†
Detroit, Mich.	.....	18.25‡
Kansas City, Mo.	2.40†	2.40†
Minneapolis, Minn.	1.55†	1.40†
Montreal	15.00‡	11.00‡
New Orleans, La.	2.40†	.....
New York, N. Y.	3.75*	3.00@3.25*
Philadelphia, Pa.	13.00‡	12.00‡
St. Louis, Mo.	17.75	17.75‡
San Francisco, Calif.	.....	1.75†
Seattle, Wash.	2.80†	.....

*Per 280 lb. bbl. (net). †Per 180-lb. bbl. (net). ‡Per ton. Refund of 10c per bbl. Minneapolis quotes brown common lump lime: Kelly Island white is $1.55, Sheboygan $1.45. New York quotes hydrated lime "on cars" in paper sacks; lump lime "alongside dealers' docks" or "on cars."

Portland Cement

Current prices per barrel in carload lots, f. o. b. cars, without bags.

Atlanta, Ga.	2.80
Boston, Mass.	3.03
Cedar Rapids, Iowa	2.48
Cincinnati, Ohio	2.54
Cleveland, Ohio	2.46
Chicago, Ill.	2.20
Dallas, Tex.	2.25
Davenport, Iowa	2.43
Denver, Colo.	2.65
Detroit, Mich.	2.47
Duluth, Minn.	2.14
Indianapolis, Ind.	2.41
Kansas City, Mo.	2.45
Los Angeles, Calif.	2.56
Milwaukee, Wis.	2.37
Minneapolis, Minn.	2.39
Montreal, Can. (sacks 20c extra)	2.40
New Orleans, La.	2.83
New York, N. Y.	2.70
Phoenix, Ariz.	3.70
Pittsburgh, Pa.	2.24
Portland, Ore.	3.05
San Francisco, Calif.	**3.03@3.55
St. Louis, Mo.	2.35
St. Paul, Minn.	2.39
Toledo, Ohio	2.48
Seattle, Wash.	2.90

NOTE—Add 40c per bbl. for bags.
** + warehouse.

Gypsum Products— CARLOAD PRICES PER TON AND PER M SQUARE FEET, F. O. B. MILL

	Crushed Rock	Ground Gypsum	Agricultural Gypsum	Stucco* Calcined Gypsum	Cement‡ and Gauging Plaster	Wood Fiber	White§ Gauging	Sanded Plaster	Keene's Cement	Trowel Finish	Plaster Board ½x32x36" Weight 1500 lb. Per M Sq. Ft.	Plaster Board ⅜x32x36" Weight 1850 lb. Per M Sq. Ft.	Wallboard. ⅜x32 or 48" Lengths 6'-10', 1850 lb. Per M Sq. Ft.
Douglas, Ariz.	.....	6.00	6.00	.....	13.00	.....	.....	.....	.....	.....	.....	.....	.....
Fort Dodge, Iowa	3.00	3.50	6.00	8.00	10.00	10.50	20.00	.....	21.30	20.00	20.00	.....	30.00
Garbutt, N. Y.	.....	.....	6.00	8.00	10.00	10.00	.....	7.00	.....	.....	.....	20.00	.....
Grand Rapids, Mich.	3.00	.....	5.00	10.00	10.00	10.00	.....	.....	31.00	.....	19.75	20.00	30.00
Hanover, Mont.	4.50	.....	6.00	10.00	.....	10.50	.....	.....	.....	.....	.....	.....	.....
Mound House, Nev.	.....	8.50	6.50	10.50@11.50	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oakfield, N. Y.	3.00	4.00	6.00	8.00	10.00	10.00	20.20	7.00+	30.75	21.00	19.375	20.00	30.00
Rapid City, S. D.	4.00	.....	.....	10.00	11.00	11.50	.....	.....	33.75	.....	.....	.....	.....
San Francisco, Calif.	.....	.....	.....	16.40	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnipeg, Man.	5.50	5.50	7.00	13.50	15.00	15.00	.....	.....	.....	.....	28.50	.....	35.00

NOTE—Returnable Jute Bags, 15c each, $3.00 per ton; Paper Bags, $1.00 per ton extra.
*Shipment in bulk 25c per ton less; ‡Bond plaster $1.50 per ton additional; +Sanded Wood Fiber $2.50 per ton additional; §White Moulding 50c per ton additional; ||Bulk; (a) Includes sacks.

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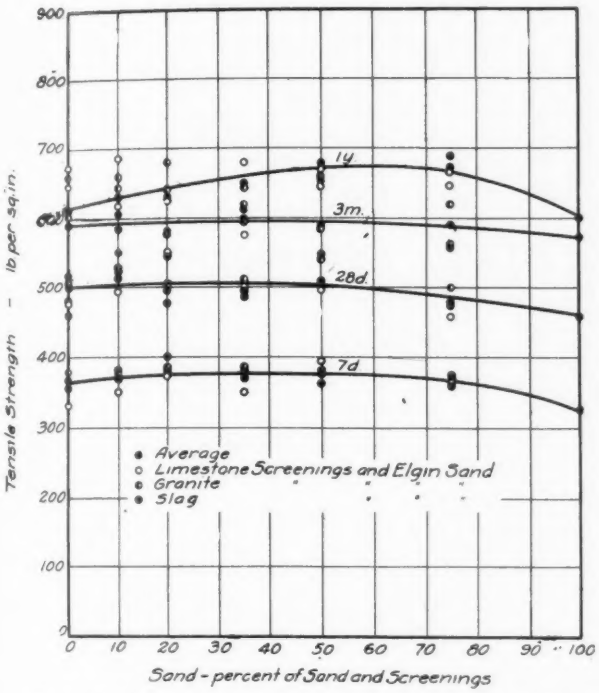


Fig. 1. **Effect of Quantity of Sand in Mixture of Sand and Screenings on the Tensile Strength of 1-3 Mortars.**—Mix 1-3 by weight. Fine aggregate; limestone, granite and slag screenings mixed with different percentages of sand. Relative consistency 1.00. Specimens stored in water; tested damp.

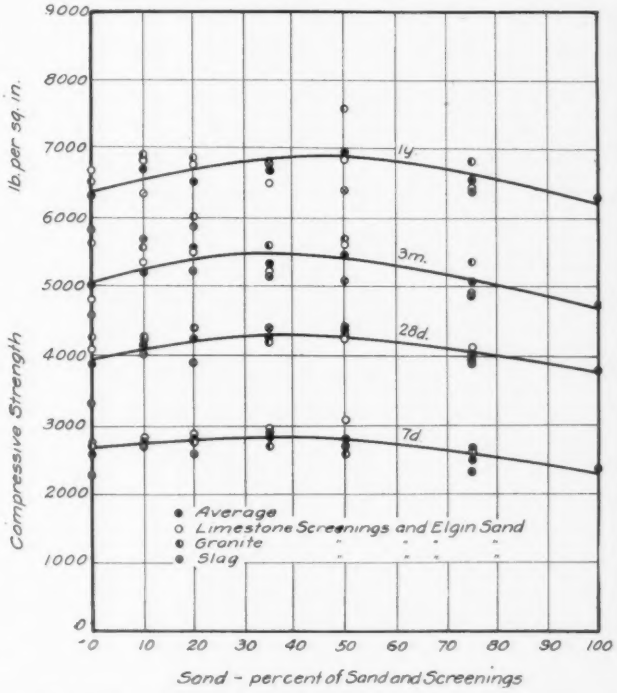


Fig. 2. **Effect of Quantity of Sand in Mixture of Sand and Screenings on the Compressive Strength of 1-3 Mortars.**—Compression tests of 2x4-in. cylinders. Mix 1-3 by weight. Fine aggregate; limestone, granite and slag screenings mixed with different percentages of sand. Relative consistency 1.00. Specimens stored in water; tested damp.

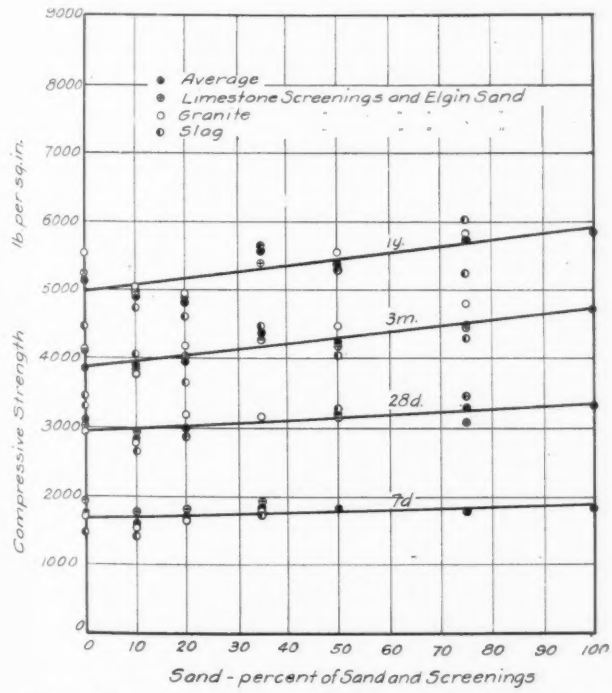


Fig. 3. **Effect of Quantity of Sand in Mixture of Sand and Screenings as Fine Aggregate in Concrete.**—Compression tests of 6x12-in. concrete cylinders. Mix 1-4 by volume. Fine aggregate; limestone, granite and slag screenings mixed with different percentages of sand. Coarse aggregate; pebbles graded No. 4 to 1½ in. Fine and coarse aggregate combined to give fineness modulus of 5.50 for mixed aggregate. Relative consistency 1.10. Specimens stored in moist room; tested damp.

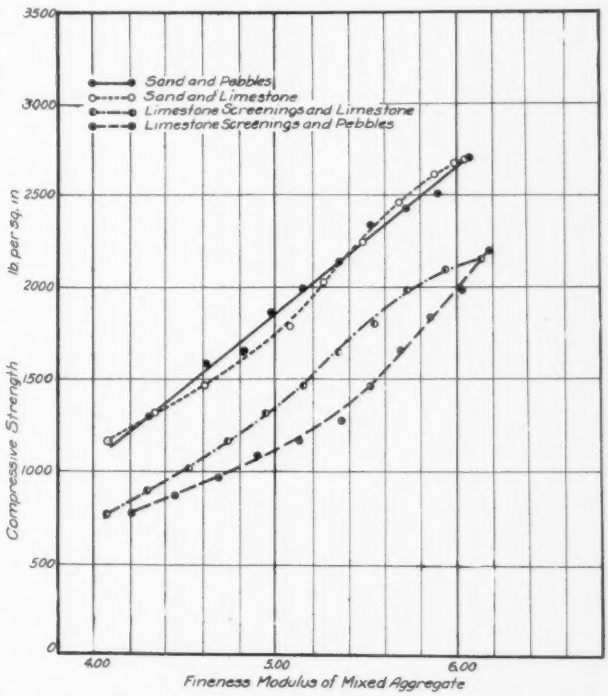

Compressive Strength lb per sq.in
Fineness Modulus of Mixed Aggregate
Sand and Pebbles
Sand and Limestone
Limestone Screenings and Limestone
Limestone Screenings and Pebbles

Fig. 4. **Effect of Grading of Aggregate on the Compressive Strength of Concrete.**—Compression tests of 6x12-in. cylinders. Grading of aggregate measured by the fineness modulus, as explained in the text. Mix 1-5 by volume. Relative consistency 1.00. Age at test, 28 days. Aggregate graded 0-1¼ in. Specimens stored in damp sand; tested damp.

News of All the Industry

Incorporations

The Missouri Red Granite Co., St. Louis, Mo., has been incorporated for $50,000 by J. M. Brod, Jr., G. F. Welsh and others.

The Charlottsville Soapstone Corp., Charlottsville, Va., has been incorporated for $100,000 by A. S. Billing, president, and F. S. Irvine, secretary.

The Salisbury Granite Corp., Salisbury, N. C., has been incorporated for $50,000 by P. A. Wallenborn, M. De Fraley and others.

The Incorporated Gravel Co., Dallas, Texas, has been incorporated for $2100 by E. R. Cantrell, A. E. Doss and E. Corenbleth.

The Hadkin Gravel Co., Lilesville, N. C., has been incorporated for $50,000 by A. Osborne, C. H. Roberts and T. T. Patterson, all of Charlotte, N. C.

The McLoon Ste. Genevieve Limestone Co., Ste. Genevieve, Mo., has been incorporated for $15,000 by T. B. Strangham, P. McLoon and F. L. McLoon.

The Midcoast Rock Co., Santa Barbara, Calif., has been incorporated for $100,000 to operate a quarry, by J. T. Degman, A. W. Belmont and F. J. Richards, all of Santa Barbara.

The Natstone Brooklyn Corp., a sand and gravel plant, Brooklyn, N. Y., has been incorporated by J. L. Watson, F. H. Butehorn and T. E. Halle, Manhattan.

The Stevens Creek Gravel Co., Cupertino, Calif., has been incorporated for $10,000.

The Anderson Sand Co., Inc., has been incorporated for $2,000 at Mobile, Ala., by O. Anderson and others.

The American Crushed Rock Co., White Sulphur, Ohio, has been incorporated by A. S. Hicker, H. Schmitt, A. C. Dustin, C. Follett and W. B. Stewart.

The Ashland Sand and Gravel Co., Boyd, Ky., has been incorporated for $100,000 by G. A. Northcutt, Huntington, W. Va., W. P. Wheeler and J. C. McLester, Ashland.

The Buffalo, Indiana Stone Corp., Buffalo, N. Y., has been incorporated for $20,000 by R. H. Tifft, J. E. Johnson and E. L. H. Nash.

The American Sand Co., Turner, Kans., has been incorporated for $100,000 by H. B. Thompson, R. B. O'Brien and L. W. O'Brien.

The Seymour Trap Rock Co., Wilmington, Del., has been incorporated for $500,000.

The Ladwig Sand and Gravel Co., Milwaukee, Wis., has been incorporated for $25,000 by O. Ladwig, O. Ladwig, Jr., and W. Ladwig.

The Alessandro Petrillo Co., Wilmington, Del., has been incorporated for $100,000 to operate quarries.

Quarries

The Cassady-Grey Granite Co., Llano, Tex., is erecting a large cableway at its quarry to be used for hoisting heavy stone from the pit, and will have a lifting capacity of 15 tons.

Little Rock, Ark.—The stone crushing plant of the Greenville Stone and Gravel Co., Williford, is shut down awaiting sufficient railroad cars to take care of its output.

The Tennessee Quarry Co., Knoxville, Tenn., has increased its capital stock to $25,000.

The Mineral Potash Corp., care of J. P. Andrews & Co., 514 Brisbane building, Buffalo, is planning the installation of crushing and grinding machinery, tramway, air compressors and other equipment at its feldspar properties, including complete quarry equipment. A fund of $300,000 is being provided for the installation.

Puxico, Mo.—F. Essen, Clayton, and W. A. White, Louisville, Ky., appeared before the Blue Sky Department for a permit for the Continental Rock Asphalt Co. of Kentucky, to sell $50,000 of its stock in Missouri. The company proposes the manufacture of road materials.

Vancouver, B. C.—The Granite Island Quarries, Ltd., near Argyle is making extensive improvements at its plant and will begin operations earlier than usual in anticipation of a busy season; 150 extra horsepower has been added to its motor equipment and a 25-ton derrick.

The Indiana Limestone Quarrymen's Association has compiled figures showing shipments for limestone from Indiana quarries during 1922 totaled approximately 9,000,000 cu. ft., the heaviest volume of business since 1912. The cutting plants throughout the entire producing region are now operating at capacity; plans are being made to resume quarry operations; prices are stable, and the outlook is bright for the immediate future.

Ellettsville, Ind.—Work at the Indiana Oolitic Limestone Quarry is progressing rapidly and the grading for the two-mile switch is about completed. A large amount of stone has been quarried and when the switch is completed will be ready for shipment.

Delphos, Ohio.—The Limestone Quarries Co. is removing the earth surface from a 12-acre tract of land where its new quarry will be just south of the Clover Leaf railroad.

The Tennesse Quarry Co., Knoxville, Tenn., has increased its capital from $10,000 to $25,000. Incorporators are L. C. Gunters, S. P. Frost, C. H. Armstrong, B. McGee and W. S. Roberts.

Colorado Springs, Colo.—The Beaver Construction Co., Denver, has opened its plant here and installed a large crusher with a capacity of 250 tons per day. The stone is being used for road building in the state.

The Lake Shore Stone Co., Milwaukee, Wis., re-elected president, G. A. West; vice-president, C. F. Pfister; secretary, L. Quarles; treasurer, A. J. Blair.

The Monmouth Stone Co., Monmouth, Ill., will start operation at its plant near Gladstone. The company has orders for more than 110,000 tons of stone to be used on the state road at Gladstone and other places.

Hagerstown, Md.—The Potomac Valley Stone and Lime Co. has sold to the Keystone Lime Co. 165 acres of land along the Potomac river for $60,000.

Dudley & Orr, El Paso, Texas, are erecting a quarry at Tiffin, estimated to cost $70,000. The company has a contract to supply 270,000 cu. yd, of crushed rock to the Texas & Pacific for ballasting. Deliveries in the next three years will probably amount to $500,000.

Samuel Given, operating quarries at Howellville, Pa., has purchased an additional 30 acres of limestone and will construct two large lime kilns.

Phosphate Rock

The Columbia Phosphate Mining Co., Wilmington, Del., has been incorporated for $100,000.

Bartow, Fla.—The Lakeland Phosphate Co.'s drying plant was damaged by fire recently to the extent of $50,000, partially covered by insurance.

Columbia, Tenn.—Phosphate rock in large quantities and of excellent quality has been discovered on the farm of John Sneed, near Enterprise. Seven shafts have been sunk and in every instance a fine grade of phosphate has been found and the veins are unusually thick. Mr. Sneed will erect a plant, and a spur track two miles long will be laid to the railroad.

Cement

Waco, Texas.—An inspection of a tract of land near here owned by the Southwestern Portland Cement Co., consisting of 200 acres, has just been made by officials of the company. The company intends to erect a plant at this location at a cost of approximately $1,500,000. Work will begin shortly. The ground which the company owns here is said to contain a practically inexhaustibile supply of limestone rock.

The Columbia Cement Co., Concord building, Portland, Ore., proposes to establish the largest cement plant west of the Mississippi river.

The Great Western Portland Cement Co., Kansas City, Mo., announces it will erect a warehouse at Mildred, large enough to provide storage space for 200,000 bbl. of cement.

The Signal Mountain Portland Cement plant, Chattanooga, Tenn., will be ready for operation about April, according to an announcement by an official of the company. The new plant will have a capacity of about 300 bbl. of cement a day and expects to produce about 2500 bbl. as soon as it gets up to production. The plant is estimated to cost $2,000,000.

The Hermitage Portland Cement Co., Chattanooga, Tenn., has let a contract for a 2000-bbl. plant. J. C. Vance is president and R. T. Miller, Chicago, Ill., is general manager.

Allentown, Pa.—The stockholders of the Lehigh Portland Cement Co. will increase its capital stock from $18,000,000 to $25,000,000. Directors elected: Gen. H. C. Trixler, E. M. Young, G. K. Mosser, Allentown; J. Dormond, Emaus, Pa.; A. Y. Gowen, Chicago.

The Clinchfield Portland Cement Co., Richmond, Va., has arranged for an increase in capital from $2,000,000 to $3,000,000 for general expansion.

The Gonzales Cement Works, Gonzales, Texas, are housed in a new factory and new machinery is being installed.

Milwaukee, Wis.—The Western Lime and Cement Co. has been awarded a contract for 10,000 bbl. of cement at $2.80 per bbl. by W. R. Callahan, city purchasing agent. This price is 46 cents above the figures of a year ago and is caused by the brisk demand.

The American Cement Plaster Co., Ft. Dodge, Kans., recently had a fire at its plant causing a loss of $200,000.

The Canada Cement Co., Ltd., Montreal, in its annual report shows a surplus of current assets and investments of $6,011,862.71, of which $2,289,430.13 is in bonds and $1,216,276.99 in cash. The directors report that business was not satisfactory, the total consumption of cement being much less than normally used in Canada. Considering that there are five other companies producing cement in Canada, the directors feel that the year's business was as satisfactory as could be expected.

Bakersfield, Cal.—Plans for a $3,000,000 cement plant at Tehachapi are being discussed by the civic commercial association. The proposal came through A. M. Frost, of the San Joaquin Light and Power Corp., Fresno. It is said the plant will be constructed by the Henry Cowell Lime and Cement Co., which owns a large lime deposit near Tehachapi.

The Lehigh Portland Cement Co.'s plant at Metaline Falls, Wash., is operating at full capacity and will continue its output of 2000 bbl. a day throughout the season.

Sheffield, Ala.—S. W. Kendall, Meridian, Miss., and others, will establish a large cement plant here. It will be built in two units, each having a daily capacity of 2000 bbl. A lime kiln will also be built. The properties will represent an investment of approximately $1,000,000 and the plant will employ about 1000 men. It is estimated the cement plant will be completed by July 1, and the lime kiln in a short time.

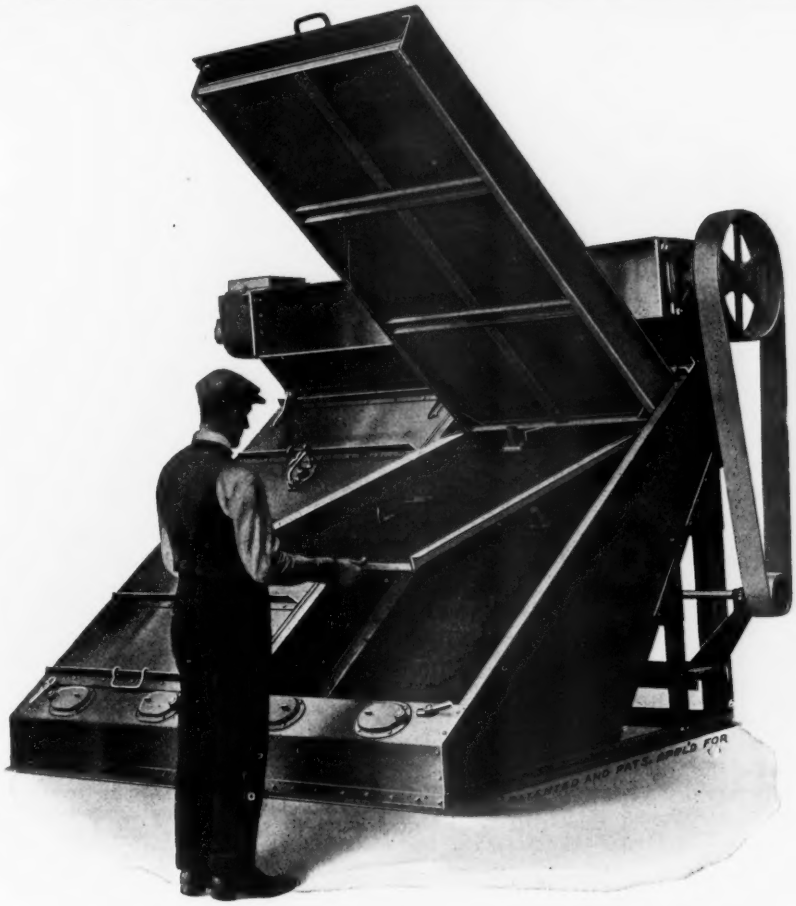
The Laramie Cement Plaster Co., Laramie, Wyo., which has been shut down for a short while, has resumed operation.

Sweetwater, Tex.—The Universal Gypsum Co., Chicago, has purchased a bed of gypsite near Rotan for $80,000. According to plans announced by C. E. Williams and J. A. Henry, Chicago, work of building a plant for the manufacture of cement, plaster and wall board will begin shortly.

Sand and Gravel

Evansville, Ind.—The county commissioners of Posey county have awarded the contract for gravel, for gravel road repair for the year to the Evansville Sand and Gravel Co., at a lower price than that of last year. The price of gravel delivered at Mt. Vernon will be $1 per yard. The Mt. Vernon plant of the Evansville Sand and Gravel Co. has resumed operations after being closed down several weeks.

STURTEVANT



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Sandvik Steel Inc., New York City, N. Y.

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Flexible Steel Lacing Co., Chicago, Ill.

BELT LACINGS
Flexible Steel Lacing Co., Chicago, Ill.

BINS
Link-Belt Co., Chicago, Ill.
Weller Mfg. Co., Chicago, Ill. (storage)

BIN GATES
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bacon, Earle C., Inc., New York City.
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Sturtevant Mill Co., Boston, Mass.
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Ensign-Bickford Co., Simsbury, Conn.
Grasselli Powder Co., Cleveland, Ohio.
Hercules Powder Co., Wilmington, Del.

BRICK MACHINERY
Shope Brick Co., Portland, Oregon.
Thayer Co., L. V., New York City, N. Y.

BUCKETS—Elevator
American Manganese Steel Co., Chicago Heights, Ill.
Hendrick Mfg. Co., Carbondale, Pa.
Link-Belt Co., Chicago, Ill.
Orton & Steinbrenner, Chicago, Ill.
Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Webster Mfg. Co., The, Chicago, Ill.

BUCKETS
Atlas Car & Mfg. Co., Cleveland, Ohio.
Clyde Iron Works, Duluth, Minn.
Industrial Works, Bay City, Mich.
Jeffrey Mfg. Co., Columbus, Ohio.
Lidgerwood Mfg. Co., New York City, N. Y.
McMyler Interstate Co., Cleveland, Ohio.
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Easton Car & Constr. Co., Easton, Pa.
Koppel Industrial Car and Equipment Co., Koppel, Pa.
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Worthington Pump & Mach. Corp., New York City, N. Y.

CAR PULLERS
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Link-Belt Co., Chicago, Ill.
Mining Machine Co., Mountville, Pa.
Weller Mfg. Co., Chicago, Ill.

CASTINGS
Kramer Bros. Fdy. Co., Dayton, Ohio.
Nortmann-Duffke Co., Milwaukee, Wis.

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Smith Eng. Works, Milwaukee, Wis.
Robins Conveying Belt Co., New York City.
Sturtevant Mill Co., Boston, Mass.
W. Toepfer & Sons Co., Milwaukee, Wis.
Universal Road Mach. Co., Kingston, N. Y.
Webster Mfg. Co., The, Chicago, Ill.

COUPLINGS
Knox Mfg. Co., Philadelphia, Pa.

CLUTCHES
Dodge Mfg. Co., Mishawaka, Ind.
W. A. Jones Fdy. & Mach. Co., Chicago, Ill.

CRANES—Crawling Tractor
Industrial Works, Bay City, Mich.

CRANES—Locomotive, Gantry
Clyde Iron Works, Duluth, Minn.
Erie Steam Shovel Co., Erie, Pa.
Industrial Works, Bay City, Mich.
Koehring Co., Milwaukee, Wis.
Link-Belt Co., Chicago, Ill.
McMyler-Interstate Co., Cleveland, Ohio.
Ohio Locomotive Crane Co., Bucyrus, Ohio.
Orton & Steinbrenner, Chicago, Ill.
Osgood Co., The, Marion, Ohio.
The Byers Machine Co., Ravenna, Ohio.

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American Pulverizer Co., St. Louis, Mo.
Austin Mfg. Co., Chicago, Ill.
Bacon, Earle C., Inc., New York, N. Y.
Buchanan Co, Inc., C. G., New York, N. Y.
Ehrsam & Sons Co. J. B., Enterprise, Kan.
Fuller-Lehigh Co., Fullerton, Pa.
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McLanahan-Stone Mach. Co., Hollidaysburg, Pa.
Morgan Engineering Co., The Alliance, Ohio.
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Pennsylvania Crusher Co., Philadelphia, Pa.
Raymond Bros. Impact Pulv. Co., Chicago, Ill.
Robins Conveying Belt Co., New York City, N. Y.
Smidth & Co., F. L., New York, N. Y.
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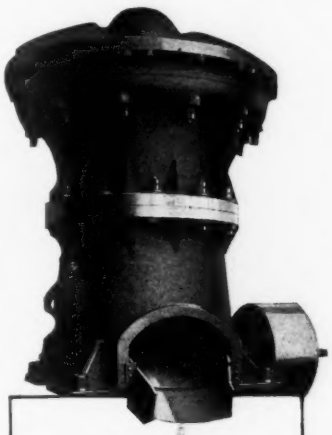
Sturtevant Mill Co., Boston, Mass.
Traylor Eng. & Mfg. Co., Allentown, Pa.
Universal Crusher Co., Cedar Rapids, Iowa.
Universal Road Mach. Co., Kingston, N. Y.
Webb City & Carterville Fdy. and Mach. Wks., Webb City, Mo.
Worthington Pump & Mach. Corp., New York City, N. Y.

CRUSHER REPAIRS—Manganese Steel
American Manganese Steel Co., Chicago Heights, Ill.
Taylor Wharton Iron & Steel Co., High Bridge, N. J.

CLUTCHES
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago, Ill.
Weller Mfg. Co., Chicago, Ill.

This Crusher Was Tested For Three Years With Hard Granite



SUPERIOR McCULLY CRUSHER

Special Features

Shaft 60 per cent. stronger than in standard gyratories.

Spider Hub absolutely rigid.

Improved dust collar keeps bottom shell clean.

Gear pump floods eccentric and gearing with oil—longer life.

Cut steel gear and pinion—less wear—less friction.

Has low maintenance cost.

The first Worthington Superior McCully Crusher was tested for three years before it was offered for sale. It was a new type of gyratory at that time (1909) and Worthington felt that three years of crushing hard granite was a necessary test before any one could be absolutely sure the crusher would do its work properly.

The fact that there are now over three hundred Worthington Superior McCully Gyratory Crushers in operation, shows that this policy of "test first, then market" has been appreciated by those who use crushers.

WORTHINGTON PUMP AND MACHINERY CORPORATION

Executive Offices; 115 Broadway, New York City

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PRODUCTS OF THE POWER AND MINING WORKS

Jaw Crushers
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Screens
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Rotary Kilns
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Blast Furnaces
Mining Equipment

W-159.8

WORTHINGTON

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Gas Engine Works, *Cudahy, Wis.*
Power & Mining Works
Cudahy, Wis.
Snow-Holly Works
Buffalo, N. Y.

Buyers' Directory
of the Rock Pr ducts Industry

Classified Directory of Advertisers in this issue of Rock Products

DERRICKS
American Hoist & Derrick Co., St. Paul, Minn.
Clyde Iron Works, Duluth, Minn.
Lidgerwood Mfg. Co., New York City, N. Y.
Mundy Hoisting Engine Co., Newark, N. J.
The Byers Machine Co., Ravenna, Ohio.

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American Manganese Steel Co., Chicago Heights, Ill.

DREDGES
Osgood Co., Marion, Ohio.

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Sanderson Cyclone Drill Co., Orrville, Ohio.
Sullivan Machinery Co., Chicago, Ill.

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American Process Co., New York City.
McGann Manufacturing Co., Inc., York, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.
Weller Mfg. Co., Chicago, Ill.
Worthington Pump & Mach. Corp., New York City, N. Y.

DUST COLLECTING SYSTEMS
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Rubert M. Gay Co., New York City, N. Y.

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Du Pont Powder Co., Wilmington, Del.
Grasselli Powder Co., Cleveland, Ohio.
Hercules Powder Co., Wilmington, Del.

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Climax Engineering Co., Clinton, Iowa.

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ENGINES—Oil
Kahlenberg Bros. Co., Two Rivers, Wis.
Power Mfg. Co., Marion, Ohio.

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R. W. Hunt & Co., Chicago, Ill.
Smidth & Co., F. L., New York, N. Y.
Schaffer Eng. & Equip. Co., Pittsburgh, Pa.
Webster Mfg. Co., The, Chicago, Ill.

EXCAVATORS
Erie Steam Shovel Co., Erie, Pa.
Koehring Co., Milwaukee, Wis.
Northwest Engineering Co., Chicago, Ill.
Schofield-Burkett Co., Macon, Ga.

EXCAVATORS—Dragline Cableway
Link-Belt Co., Chicago, Ill.
Northwest Engineering Co., Chicago, Ill.
Sauerman Bros., Chicago, Ill.

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Dodge Mfg. Co., Mishawaka, Ind.
Jeffrey Mfg. Co., Columbus, Ohio.
Link-Belt Co., Chicago, Ill.
W. A. Jones Fdy. & Mach. Co., Chicago, Ill.

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GRATES
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GREASE
Keystone Lubricating Co. The, Philadelphia, Pa.

GRIZZLIES
Robins Conveying Belt Co., N. Y. City, N. Y.

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J. B. Ehrsam & Sons Mfg. Co., Enterprise, Kan.

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Clyde Iron Works, Duluth, Minn.
American Hoist & Derrick Co., St. Paul, Minn.
J. S. Mundy Hoisting Engine Co., Newark, N. J.
Lidgerwood Mfg. Co., New York City, N. Y.
Link-Belt Co., Chicago, Ill.
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Thomas Elevator Co., Chicago, Ill.
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Weller Mfg. Co., Chicago, Ill.

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Celite Products Co., Chicago, Ill.

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Webster Mfg. Co., The, Chicago, Ill.
Weller Mfg. Co., Chicago, Ill.

LIME KILNS
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Link-Belt Co., Chicago, Ill.
Orton & Steinbrenner, Chicago, Ill.

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Baldwin Locomotive Works, The, Philadelphia, Pa.
Fate-Root-Heath Co., Plymouth, Ohio.
Hadfield-Penfield Steel Co., Bucyrus, Ohio.
Ironton Engine Co., Ironton, Ohio.
Lima Locomotive Works, New York, N. Y.
Vulcan Iron Works, Wilkes-Barre, Pa.
Whitcomb Co., Geo. D., Rochelle, Ill.

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McMyler Interstate Co., Cleveland, Ohio.

LUBRICANTS
Keystone Lubricating Co. The, Philadelphia, Pa.

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Hardinge Co., New York City, N. Y.
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Sturtevant Mill Co., Boston, Mass.

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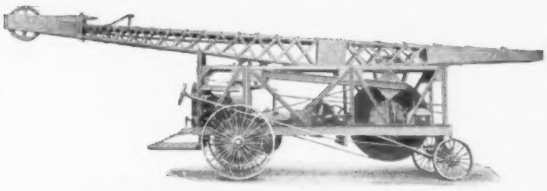
MOTOR TRUCKS
Traylor Eng. & Mfg. Co., Allentown, Pa.

Armstrong Manufacturing Company

310 Chestnut Street **Waterloo, Iowa, U. S. A.**

"All-Steel" Blast Hole Drills



Built in Both Tractor and Portable Types

The greatest improvement in blast hole drills that has been made in fifty years! Will penetrate hardest formations! Sold on thirty days trial. Electric or gasoline tractor, also portable, complete with tools, delivered at your station anywhere east of the rocky mountains, freight prepaid, on easy terms.

All steel construction. Frame made of channel beams and angles, trussed and hot riveted. Wheels and axles of standard steel type. Derrick; latticed steel. All steel gears. Equipped with worm gear feed. Built like a steel bridge. **No danger of damage from flying rock from blasts. No danger from fire!**

Equipment

Power unit; electric motor or four-cylinder gasoline engine, of standard makes, to furnish both traction and operating power. Armstrong patented wire line derrick uses steel cable at half the cost of manila cable and lasts four times as long. Armstrong special controls enable the operator to manage entire operation from the drilling end.

A Blast Hole Special

The Armstrong New "All Steel" Blast Hole Drill is **"Built to stand the abuse of quarry use."** The strength, stability of construction, ease of control, durability and more than 55 years of drill manufacturing experience that are built into this machine make it the leader in its line. It is especially built to withstand the grinding torture which Blast Hole Drills are called upon to endure and will penetrate the hardest formations without a hitch.

Specifications

No. 50 Armstrong "All Steel" Blast Hole Drill, shown above: Length 22 ft.; width 7 ft. 10 in.; height of derrick, 32 ft.; band wheel, 6 ft. in diameter, 11 in. face; power, electric motor or four-cylinder gasoline engine (of standard makes), buyer's option.

No. 45 Armstrong "All-Steel" Blast Hole Drill, portable type, same specifications as above.

Special Features

1. All-steel frame with every piece hot riveted in place.

2. Wire Line Derrick constructed entirely of steel, which uses wire line exclusively and saves 75 per cent of the cable expense.

3. Low-down construction with all bearings mounted directly on the main sills.

4. Band Wheel mounted between two heavy steel sills, with no overhang or side draft.

5. Crown Sheave, Spudding Sheave and Heel Sheave, all more than two feet in diameter. Stops cable breakage.

6. A clutch controlling the drilling motion, which is built to carry five times its normal load and **guaranteed against breakage from any cause for the life of the machine.**

7. More than 55 years' drill manufacturing experience built into every Armstrong Drill.

8. Sold on thirty days' trial, on easy terms, at a delivered price, f. o. b. buyer's station east of Rocky Mountains.

In writing for information please state depth of quarry face and character of rock formation. Write today for Bulletin No. 81. Its FREE and worth having

Buyers' Directory
of the Rock Products Industry

Classified Directory of Advertisers in this issue of Rock Products

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Nortmann-Duffke Co., Milwaukee, Wis.

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Hercules Powder Co., Wilmington, Del.

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Webster Mfg. Co., The, Chicago, Ill.

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Weller Mfg. Co., Chicago, Ill.
W. A. Jones Fdy. & Mach. Co., Chicago, Ill.

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Rubert M. Gay Co., New York City.
Raymond Bros. Impact Pulv. Co., Chicago, Ill.
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Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Weller Mfg. Co., Chicago, Ill.

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Erie Steam Shovel Co., Erie, Pa.
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American Manganese Steel Co., Chicago Heights, Ill.
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Jones

New Speed Reducer Catalog Number 26

NOW READY FOR DISTRIBUTION

An entirely new edition. The information contained therein is of exceptional value to *Consulting Engineers, Superintendents, Chief Engineers, Master Mechanics;* in fact, to anyone who specifies mechanical drives for factories, mills, mines or plants.

It is our aim to place all copies of this edition in the hands of those who are vitally interested in Speed Reduction Problems. We ask that requests for copies be made on business stationery giving name and title of individual to facilitate prompt delivery.

In preparing this new and most complete treatise on Speed Reduction Drives, our intention was to make it the standard work of its kind and we take particular pride in presenting it to you.

You will find embodied therein, technical and practical information, complete descriptive matter and illustrations of typical drives.

The installation section presents pictorially Reducer Drives in many large industrial plants.

Dimensions, weights and horse power ratings for complete Speed Reduction Sets are shown.

W. A. Jones Foundry & Machine Company

Main Office and Works

4443 West Roosevelt Road · Chicago

Branch Sales and Engineering Offices in Principal Cities

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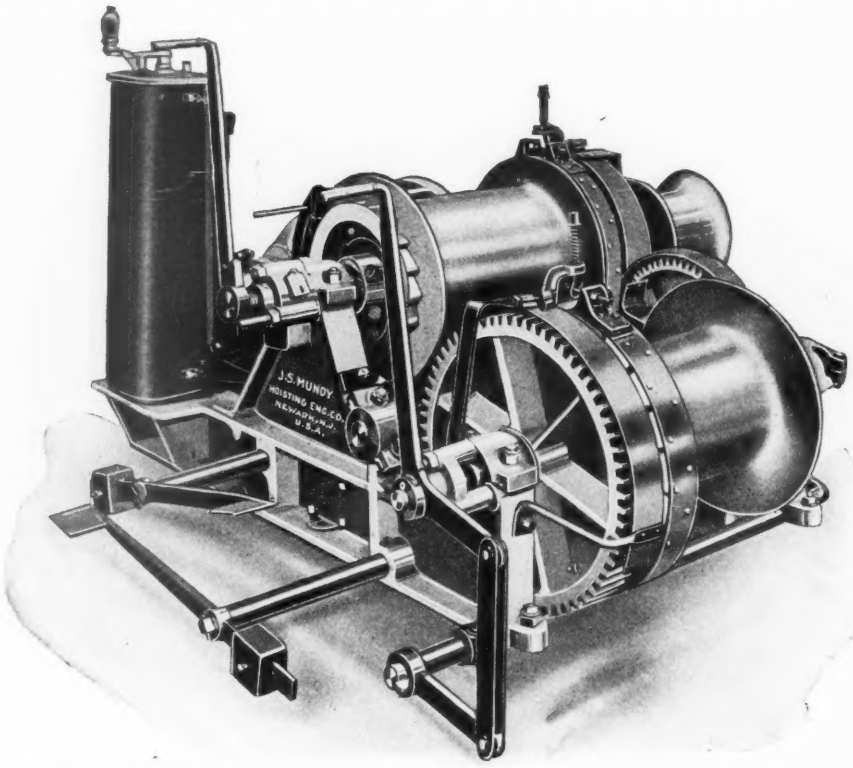
MUNDY
ESTABLISHED 1869

Save Money with MUNDY EXCAVATOR HOIST



EQUIPPED WITH NON-BURN MOISTURE PROOF "ASBESTALL" FRICTION BLOCKS "ASBESTOLIN" LINED BRAKES

The above two-speed hoist was developed for drag line work, but can also be used economically for drag scrapers and ditchers.

The lower or inhaul drum carries the loaded bucket to the dump at a slow speed. The top or outhaul drum returns the bucket to the end of the haul at a high speed.

SUCCESSFUL PERFORMANCE · FOR · A.G.C. OF A.

Spot Your Cars With Mundy Improved Car Mover

J. S. MUNDY HOISTING ENGINE CO.

New York Sales and Export Office: 30 Church St. NEWARK, NEW JERSEY, U. S. A.

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Concrete Products Opportunities

Sand, Gravel, Crushed Stone and Slag Producers Have Advantages as Manufacturers of Established Building Construction Necessities

FEW concrete aggregate producers seem to realize the tremendous strides that have been and are being taken in the development and use of concrete building products. Last year about 6,000,000 bbls. of portland cement went into the manufacture of concrete building blocks and bricks of various kinds. This year the Portland Cement Association is concentrating its efforts more than ever before to extend the use of concrete building products.

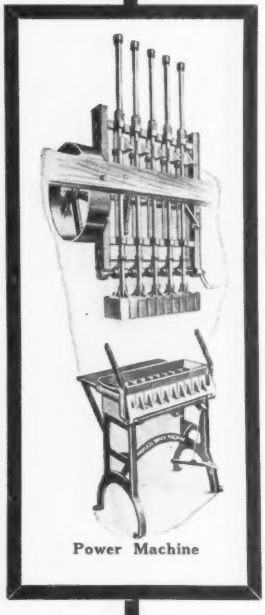
Somebody in your locality is going to profit from this great development—probably some small operator who buys his aggregate materials or produces them by a one-horse expensive operation—unless you get busy and convert some of your waste material into money.

You have all the facilities for manufacturing and selling concrete building products at a better profit than any competitor. The chances are you have thousands of tons of waste products—fine sand, stone screenings, etc.—which will cost you only the price of reclamation. You have credit. You are a going concern. You have a producing or manufacturing organization. You have a sales organization. You have established business connections.

With the scarcity of labor now universally prevalent you can not allow your employes to waste a single working day. Give them a chance to be employed in making more money for you! Put in a concrete-building products plant! Invest waste materials, idle plant and organization in adding to the volume of your business.

SERVICE is the keynote of any modern business. Why end your service with the delivery of aggregates when the same customer must look elsewhere for finished concrete products. Investigate the concrete products business. It will pay every quarry, sand and gravel pit, and slag plant operator to investigate.

PEERLESS Cement Brick MACHINE



Power Machine

1923 Will Reward the Efficient!

Don't Waste Labor, Time or Materials!

Labor is Scarce and High-Priced. Time is Priceless. Materials Represent an Investment of Both.

Cement and a Peerless Cement Brick Machine is all any producer needs to make a high class face, as well as common, brick that will market readily and undersell any clay face brick on the market and make attractive profits.

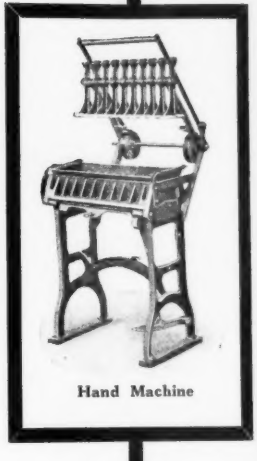
Not only that, but a wide variety of faces is possible with this machine, making it easy to satisfy any whim or fancy of the architect, builder, or owner. All brick made face down and delivered face up.

I positively guarantee more perfect brick can be made in a day on the Peerless Machine than on any other machine on the market.

Our PEERLESS POWER MACHINE beats them all. Tamps ten brick perfectly in four seconds. 10,000 to 12,000 per day. One man operates it.

I install power plants complete; any daily capacity desired.

Write for free illustrated catalog



Hand Machine

L. V. THAYER, Sole Distributor, 27 W. 43rd St., New York City

MANUFACTURE SHOPE BRICK
FROM YOUR
WASTED SCREENINGS

Clinton Court Apartments, Walla Walla, Wash.
E. T. Osborn, Architect, Seattle, Wash.

QUALITY

BEAUTY

UTILITY

IMPERVIOUS

FIRE RESISTING

$35,000,000.00 Expended in 1922 for Face Brick

The manufacturers of Shope Brick are getting their share of this great fund. The above beautiful modern apartment house is faced with the BUFF ORIENTAL ROUGH TEXTURE SHOPE CONCRETE FACE BRICK. It is one of the many big jobs in which Shope Brick were used in 1922.

The manufacture of Shope Brick is a high grade, profitable, permanent business. It is a valuable monopoly which you may control in your territory.

We sell Shope Brick Machinery to only one manufacturer in each territory

Write today for catalogue and information on your territory

SHOPE BRICK COMPANY
Portland, Oregon

An "Industrial" Crane owner writes, "In six months we saved more than the purchase price of our crane."

Stripping off burden with dragline also used for underwater digging.

"Industrial" Crane owners report 150 to 200 tons sand gravel handled daily. 650 yards crushed stone unloaded daily from cars.

Convention reports prove that with a great percentage of the trade it is costing 100 per cent or more for HANDLING than the actual value of the finished product.

"INDUSTRIAL" Crane users report handling costs from 7 per cent to 10 per cent of the value of the finished product.

And always available for other work, such as pile-driving, grab-bucket, drag-line, hook and block, shovel, switching cars and loading trucks.

"INDUSTRIAL" CRANES are steam, gasoline or electrically operated on rails or Crawling Tractor.

For Reliability, Speed and Hard Service Buy an "Industrial"

Write for Illustrated Catalog No. RC109

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BAY CITY, MICHIGAN.

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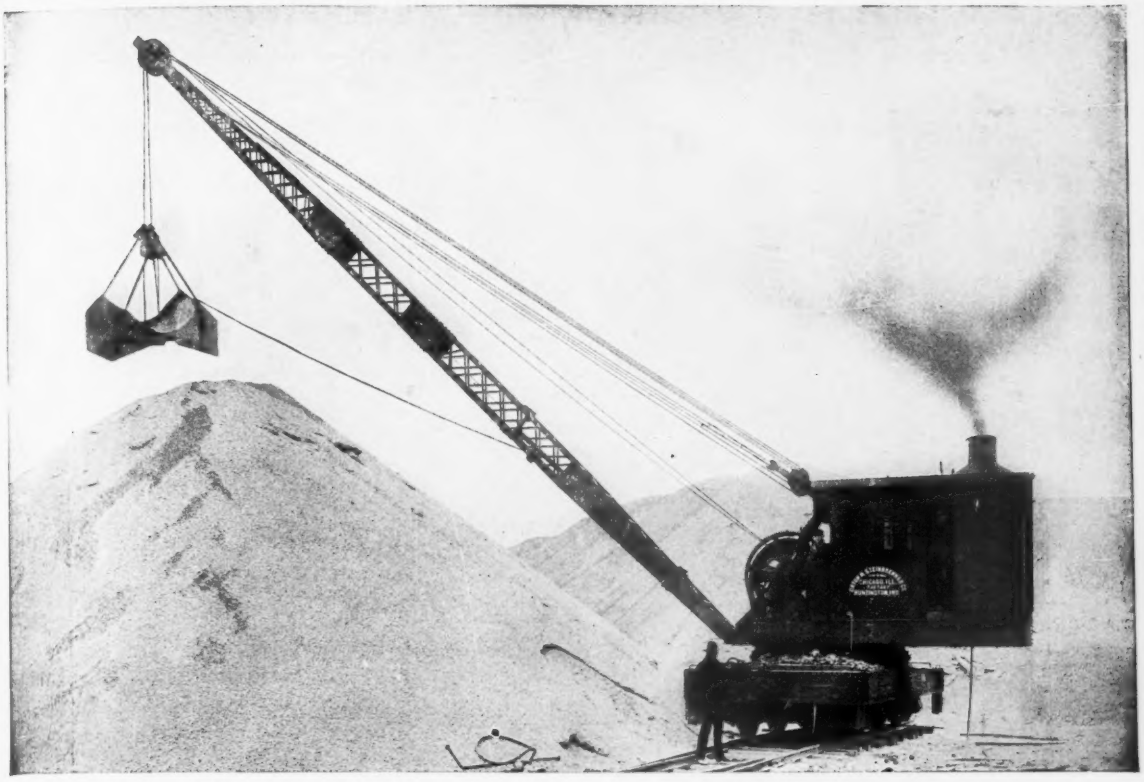
Locomotive, Erection and Wrecking Cranes, 5 to 200 tons capacity. Pile Drivers, Pillar Cranes, Transfer Cranes, Gantry Cranes Crawling Tractor Cranes, Rail Saws, Grab Buckets, Double-Acting Steam Pile Hammers, Wood Grapples



Assured Mechanical Excellence

According to a report of the Federated Engineering Societies on the elimination of waste in industry, management is responsible for the unnecessary expenditure of billions of dollars annually.

A large part of this waste is due to the use of man power, and the use of inefficient, poorly designed and constructed machinery for unproductive work—the handling of materials.

You can avoid wasteful effort at your plant by installing an O. S. Dependable Crane.

These machines are sound in construction and design. They are strong, steady and reliable. They can be depended on to move your materials at the lowest possible per ton cost.

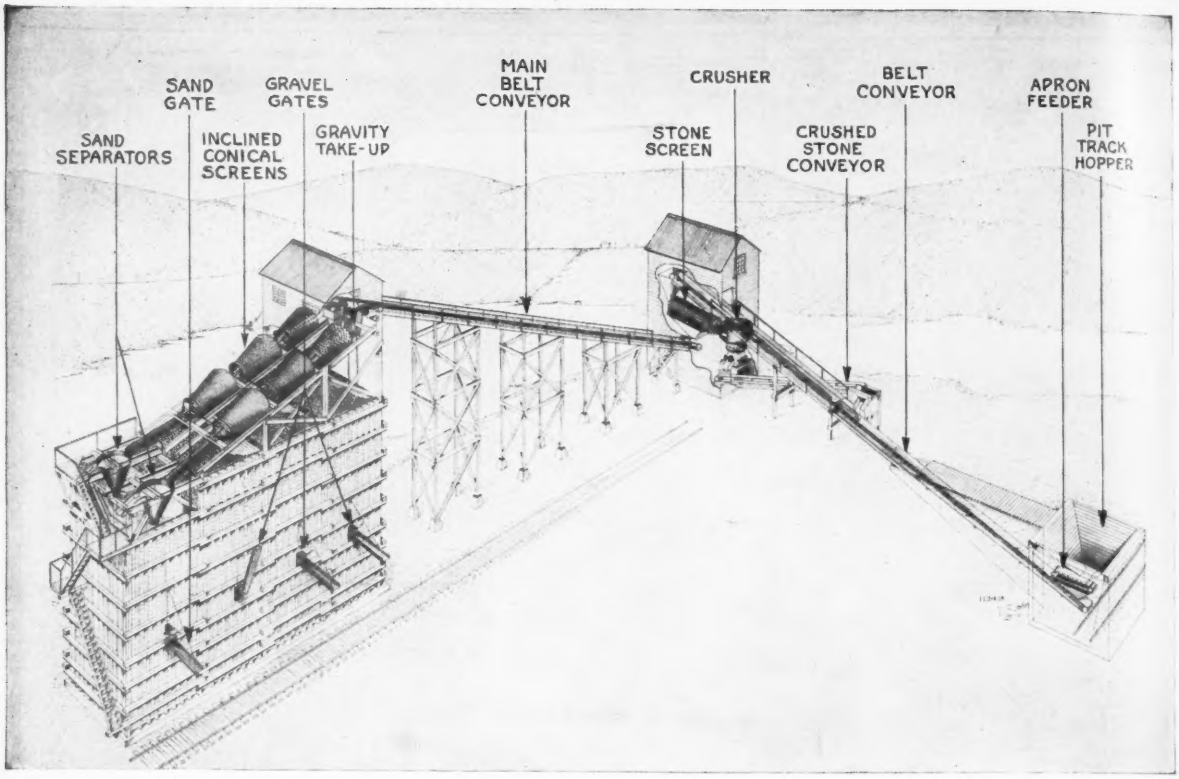
We would like to send you a copy of our catalog containing complete information concerning this remarkable crane, together with a great number of views of the O. S. on the job.

O·S

ORTON & STEINBRENNER COMPANY

Manufacturers of Cranes—Grab Buckets—Crushers

Offices—Chicago, Illinois **Factory—Huntington, Ind.**



To the Sand and Gravel Plant Operator

Link-Belt engineers have spent years in the study and development of methods for the efficient production of sand and gravel. Out of this experience they have learned what to do and how to do it.

We take full responsibility for the work from the start to the completion of the plant. The entire layout and design is by our own engineers and all the machinery is manufactured in our own modern shops.

Each Link-Belt plant is built to secure the greatest commercial advantages for its owners—whether the desired output be 10 or 300 carloads a day.

Each plant has its individuality, and the details of design make it the most efficient for its work, from every standpoint—economy of operation—high quality of material—simplicity—durability—reliability, etc.

Link-Belt screens, scrubbers, sand separators, excavators, spouts, gates, feeders, water pans, belt conveyors, bucket elevators, etc., are features of Link-Belt plants that earn dividends for their users.

If you contemplate additions to, or changes in your present equipment, or a new plant, why not put your problem up to our engineers?

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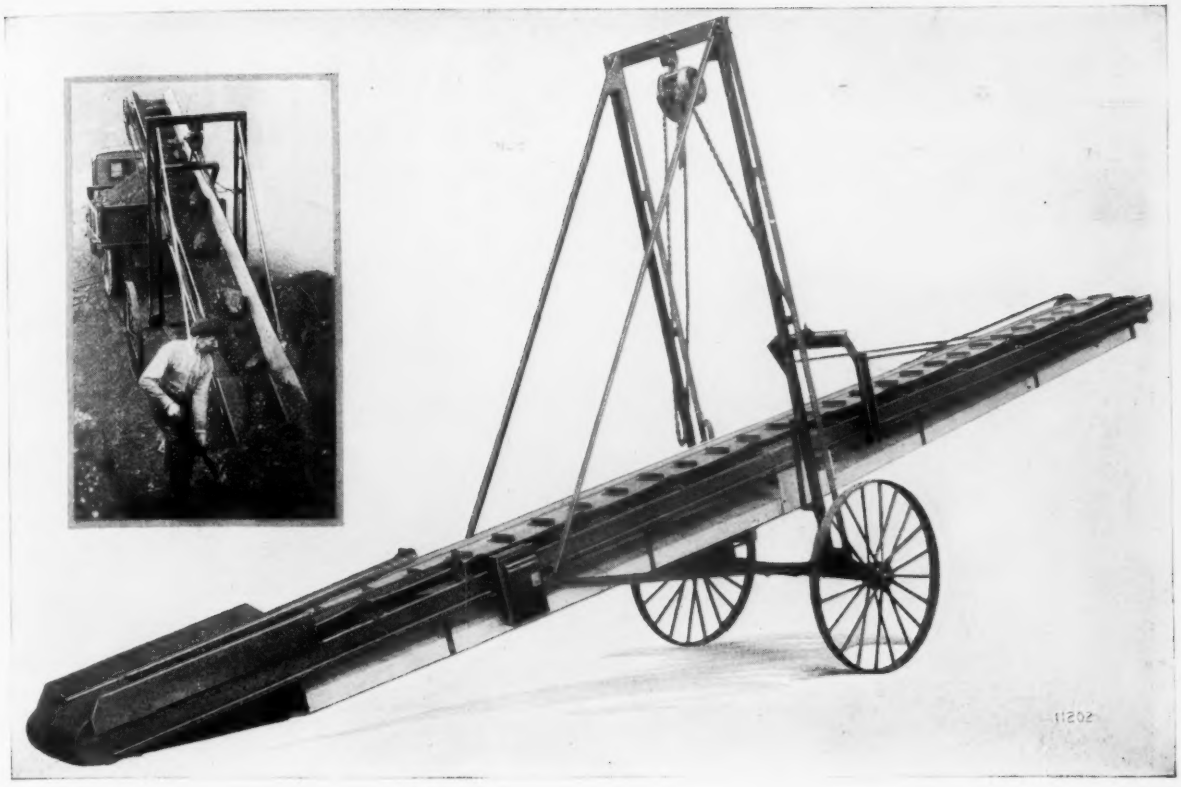

THE "CUB"—A LINK-BELT LOADER—$585.00

FEATURES

Simplicity of design.
Length of conveyor, 21 ft.
Substantial construction—weighs about twice as much as some machines of this type.
18" wide belt, giving large carrying capacity.
Belt guaranteed against cutting or fraying.
Wide loading hopper at foot of conveyor is hinged—easily and quickly opened.
Requires little power—2 H.P. motor, 2 or 3 phase, 60 cycle, A. C.

HERE'S a seven-hundred-dollar Link-Belt Portable Belt Conveyor at our new low price—$585.00, F. O. B. Philadelphia. It is one of our standard types, built to the high Link-Belt standard. It is guaranteed.

Increased production, due to our large volume of sales, has made this low price possible.

Even if you load only a small quantity of material —at intervals—can you afford to pass up an opportunity like this? Fill out and return the coupon.

1187

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☐ We handle ..... tons of ..... per .....from..... to .....

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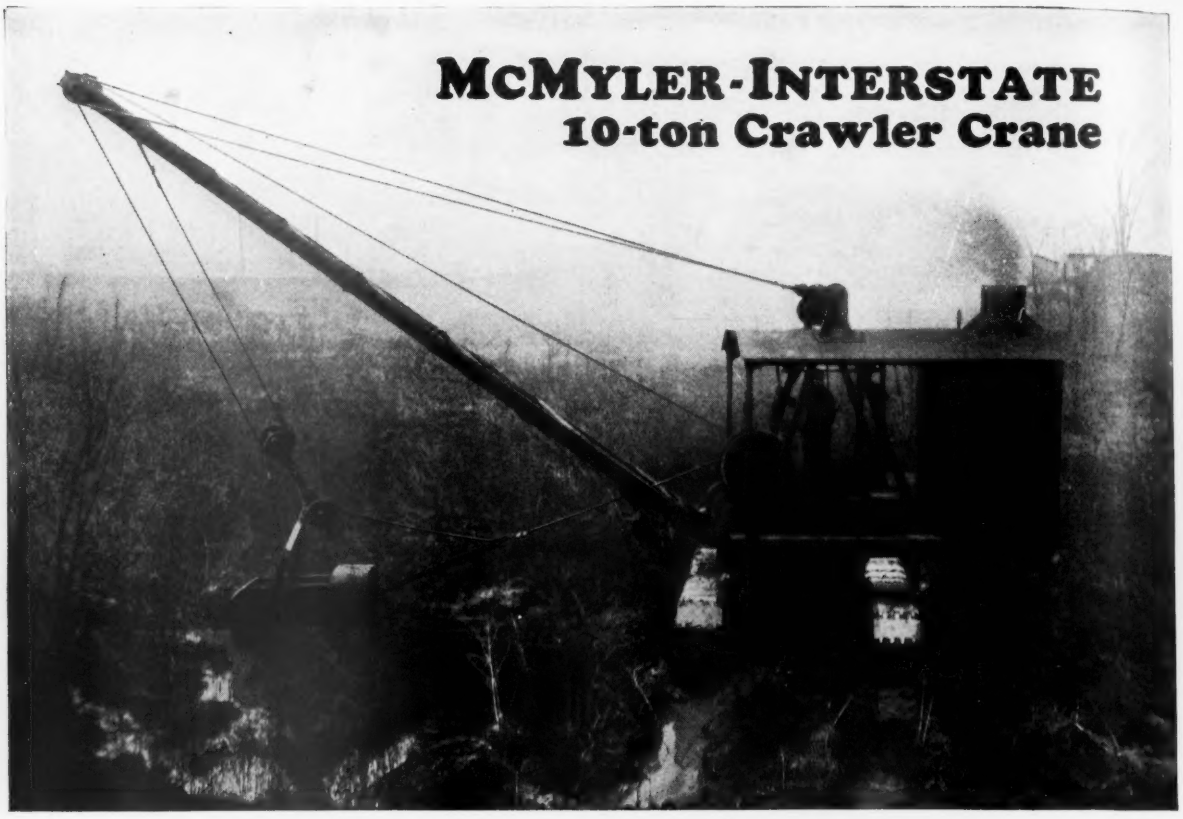

A Man's Size Mobile Crane

Here's a crane that will go anywhere! It climbs easily over railroad tracks, crawls without hesitating through sand and mud, up steep grades and down. It will turn around almost within its own length. Regardless where the job may be, the McMyler-Interstate Crawler Crane is ready to go there.

For highway construction, road grading, excavating, back filling, building and construction work, this crane is on its toes, ready for each new job as rapidly as buckets can be changed. In manufacturing plants it will handle coal, sand, crushed stone and similar bulk materials. Or with a lifting magnet it will load, unload and store scrap iron and steel. No matter how great the variety of your work, you will find this crane a capable helper.

Construction that is sturdy and generous in every detail makes this crane one that will stand up under hard work, day in and day out, allowing the operator to give his full time to production.

Booms: 30, 35 and 40 feet; traction wheel mounting if desired; steam shovel attachment available; single line pull, 10,000 lbs.; hoisting speed, 200 ft. per min.; travel speed, 100 ft. per min.

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Shovel always ready to dig.
Does not have to face blasting.
Moved back quickly and easily.
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Can always dig at most effective distance from bank.
Lighter work for pitmen.
Saves from 2 to 4 pitmen, sometimes more.

Bucyrus Caterpillars are backed by over ten years' successful experience in building caterpillar mounting for shovels and draglines.

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BUCYRUS COMPANY, South Milwaukee, Wis.
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Are you sure you are getting the most for the least?

. . to provide each user with the particular explosive that will do *his work* best and at least expense. That principle is the foundation of the du Pont Company's success—

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Nitroglycerin, ammonia, gelatin and other types of explosives designed to meet every blasting requirement at least expense.

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CORDEAU-BICKFORD Detonating Fuse

A Large Blast consisting of 156 Well Drill Holes of average depth of 26 feet

Wherever the well drill method of blasting is used, Cordeau-Bickford should be used to get the best results.

Cordeau-Bickford Detonating Fuse is run from the top to the bottom of the drill hole in continuous contact with the explosive charge.

Loading large blasts is simplified when Cordeau is used and the time of loading is materially reduced.

The use of Cordeau makes the operating of a quarry safer and reduces the blasting cost because of the quick and more complete detonation of the explosive charge.

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Big Blast Hole Drills of the Well Driller Type

Products

Big Blast Hole Drills of the well driller or cable tool type, built in traction or non-traction styles, equipped with gasoline, electric, steam or compressed air power. Drilling and fishing tools and drilling supplies.

Cyclone No. 14 Big Blast Hole Drills

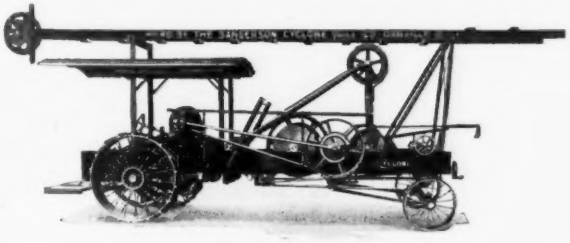
Cyclone No. 14 Big Blast Hole Drills are especially built for quarry work, differing from the ordinary well drill both in design and construction. They will operate heavy tools at a speed of 60 to 63 strokes per minute, essential for efficient results. The metal operating parts are CAST STEEL; the wood parts are best grade straight grained Oregon fir; all shafting is cold rolled steel. There are two sizes—No. 14 Standard and No. 14 Junior.

The No. 14 Standard Drill

The No. 14 Standard drill, the largest size, is recommended where maximum results in footage are desired. It will carry drill stems 4, 4¼ or 4½ inches in diameter by 20 feet long with drill bits for 5, 5⅝, 6 inch or even larger holes. For limestone quarries of daily tonnage capacity of 600 tons or over and on extremely hard rocks such as granite, trap rock or quartzite, the No. 14 Standard should be employed.

The No. 14 Junior Drill

The No. 14 Junior drill will handle 3, 3¼ and 3½ inch drill stems, 20 feet long with bits for 4, 4¼, 4½ or 5 inch holes. It is suitable for quarries producing limestone, sandstone, shale, cement rock where the



No. 14 Electric Traction Drill

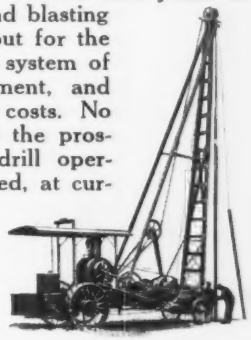
tonnage requirements range from 100 to 500 tons of raw material or in plants of large capacity where the rock moving conditions necessitate smaller blast holes and closer spacing.

Cyclone Drilling Tools

All drilling and fishing tools furnished with Cyclone Blast Hole Drills are made in our own factory, where we can control the material and workmanship that go into them and are thus in a position to cover them with a rigid guarantee.

Cyclone Service

One phase of Cyclone service is the sending of a practical sales engineer—one who has had years of experience in quarry drilling and blasting—to look over the quarry layout for the purpose of recommending the system of operation and drilling equipment, and estimating drilling and blasting costs. No obligation is thus incurred by the prospective buyer. Experienced drill operators are supplied, when desired, at current wage rates. Drilling tools and spares are shipped immediately from stock. Assistance in solving any drilling and blasting problems arising after the installation of the drill will be furnished.



No. 14 Gasoline Traction Drill

Cyclone Guarantee

Cyclone Big Blast Hole Drills are guaranteed to drill more hole at less cost, all costs considered, and to live longer than any other big blast hole drill on the market. This is not a paper guarantee. It will be put in any sales contract made, or an outfit will be placed on your work in competition with any or all other makes of drills. If the Cyclone does not outdrill and outwear the other makes of drills, we will remove it from your job without cost or risk to you.

Catalog B-45—Big Blast Hole Drills

This is a 100-page book, the first 40 pages of which deal with semi-technical information pertaining to big blast hole drilling, including cost data. The balance of the book describes in detail Cyclone No. 14 Drills and the drilling tools used with them. Write for a copy.

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Perforated Steel Screens
For Successful Operation

Our 19 years in the Perforated Metal field has given us the experience, equipment and technical knowledge to supply the crushed stone branch of the non-metallic mineral industry with screens of the kind and quality that will produce a perfectly sized product at a low cost.

We carry in stock 500 tons or more of steel plates and sheets that enable us to fill rush orders promptly, and we take great pride in our ability to supply repair and renewal parts quickly and correctly.

Try Us With Your Next Order

CROSS ENGINEERING COMPANY

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Section of Rotex No. 9

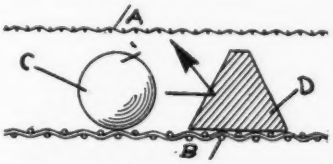
ROTEX
Compact Sifters

Here at last is the new Rotex Compact Sifter—the machine many have been waiting for—the machine that will astonish even those accustomed to seeing the best in mechanical achievement.

Rugged, responsive; strong, yet light; an ideal machine for the continuous, uniform separation of coarse or finely ground material either wet or dry.

The engraving below illustrates the basic feature of the Rotex—a series of inclined surfaces for causing many solid rubber balls to be thrown upward against the under side of the nearly level gyrating sieve fabric, an action that prevents a gradual closing up of the sieves.

We guarantee the Rotex will sift more per unit of sieve area than any other type of sifter, and we will gladly try this out with other makes to prove our assertion.

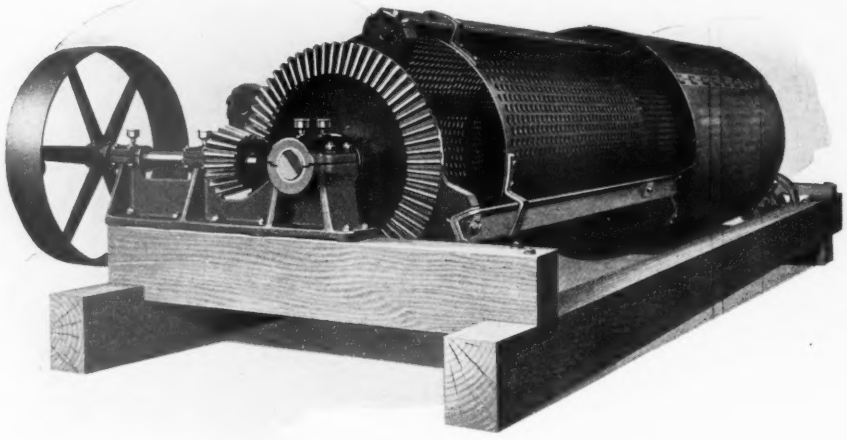


A—Sifting cloth or fabric.
B—Coarser, ball supporting screen.
C—The ball flying about under the rotating action of the screen hits the inclined surface D and is deflected upward, hitting the sifting fabric.

Write for information concerning our 30-day trial offer. It will be found interesting to all producers of non-metallic minerals whose products pass meshes between ½" and 300 per lineal inch.

THE ORVILLE SIMPSON COMPANY

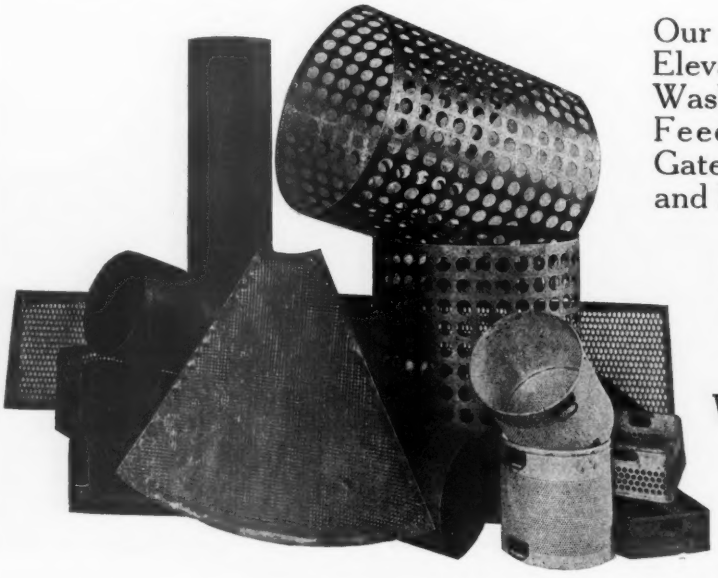
1256 Knowlton Street **Cincinnati, Ohio**



Toepfer Products

If there is any secret about the high investment value of Toepfer Products and about the tremendous hold they have on quarry operators, it can be explained by the simple fact that they are especially long-lived, especially faithful in service.

Back of it all, of course, is the way they are built. The best engineering brains, backed by a thorough knowledge of the conditions, build them to stand up under the use and frequently the abuse they receive in the hands of producers.

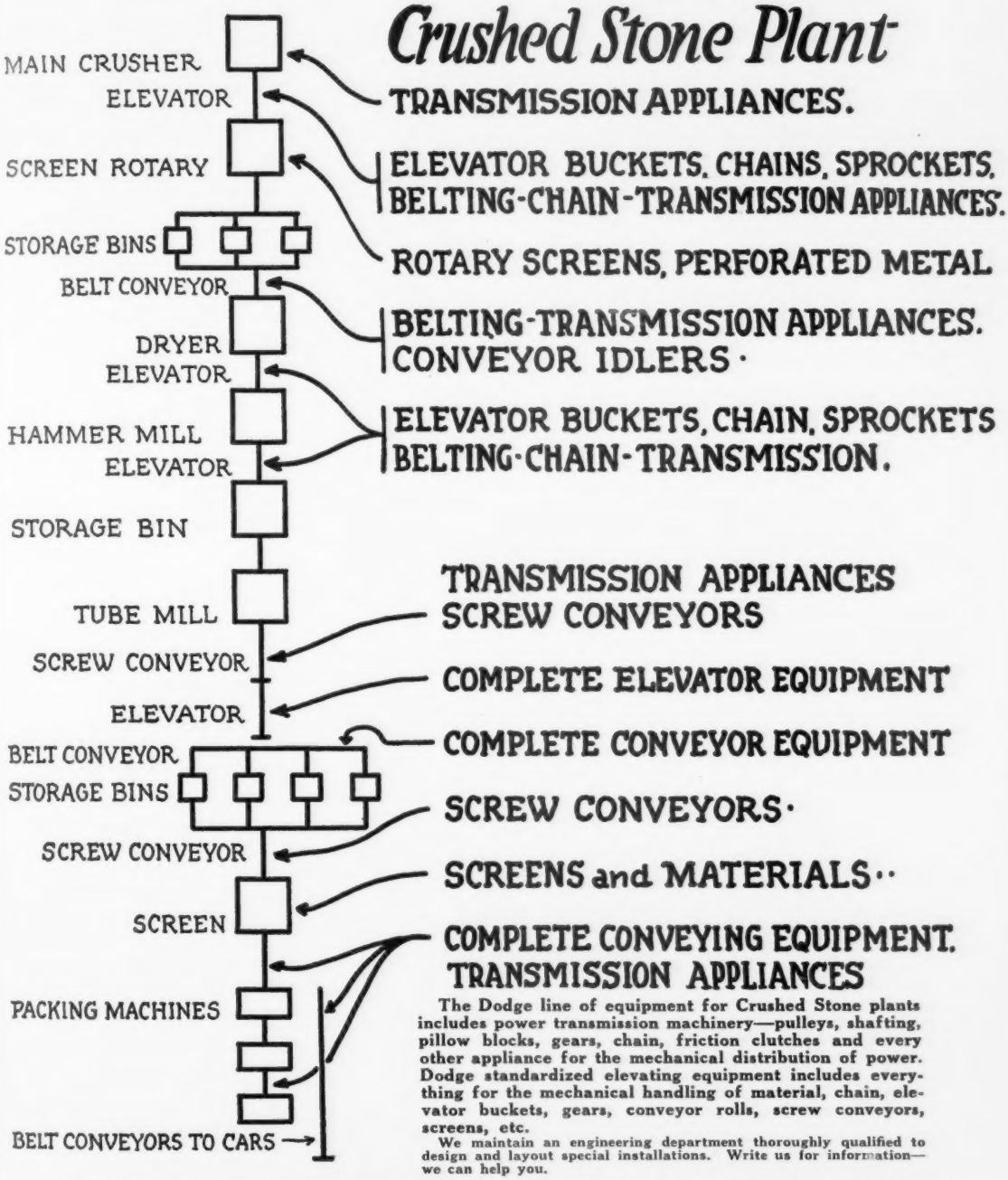


Our products also include Elevators, Sand Washers, Washing Screens, Grizzlys, Feeders, Conveyors, Bin Gates, Perforated Metals, and Hydrators.

Send in your order for screen replacements. You will get the service you demand.

W. TOEPFER & SONS COMPANY
80 Menomonee Street
Milwaukee, Wis.

DODGE EQUIPMENT
in the
Crushed Stone Plant



The Dodge line of equipment for Crushed Stone plants includes power transmission machinery—pulleys, shafting, pillow blocks, gears, chain, friction clutches and every other appliance for the mechanical distribution of power. Dodge standardized elevating equipment includes everything for the mechanical handling of material, chain, elevator buckets, gears, conveyor rolls, screw conveyors, screens, etc.

We maintain an engineering department thoroughly qualified to design and layout special installations. Write us for information—we can help you.

DODGE MANUFACTURING CORPORATION

GENERAL OFFICE: MISHAWAKA, INDIANA: WORKS, MISHAWAKA, IND, ONEIDA, N.Y.

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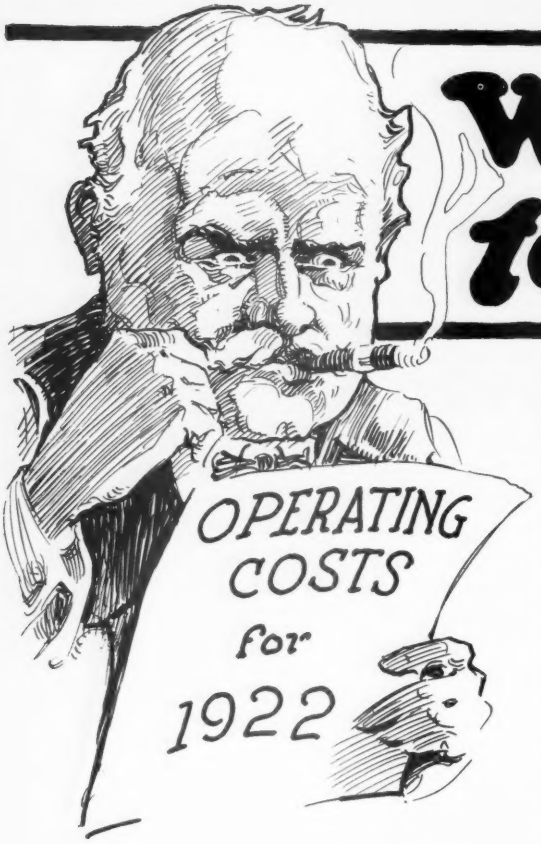


Were They too High?

A SCHOFIELD-BURKETT Excavator will hold your cost of stripping or pit production to the lowest possible level.

One firm, in removing overburden to a depth of thirty feet, found that with the Schofield-Burkett they were able to reduce the actual cost to 6½c per cubic yard. This is but one instance. There are any number of these excavators throughout the country that have proved unusually successful in service where other machines have failed.

We make excavators of any capacity up to six cubic yards. Any one of them can be operated with a laborer or two. In digging, gathering, loading, and in removing overburden, Schofield-Burkett Excavators will solve vour material handling problem.

Consult with our engineering department

The Schofield-Burkett Excavator Bucket shown on the right will automatically load any material that any other machine of the same capacity will load, and do it much less expensively, requiring but two men and half a ton of coal for each ten hours. It will load 100 to 1000 yards, according to size of machine.

We have a special proposition to make. We agree to superintend installation of a machine for you, and demonstrate that it will load your material more economically than any other method.

Can you afford to be without this?

SCHOFIELD-BURKETT CONSTRUCTION CO.

Macon, Georgia

The A. J. ALSDORF CORPORATION, 404 South Wells Street, Chicago

Representative in Illinois, Michigan, Indiana, and Exclusive Foreign Distributors

Is Your Kind of Material-Handling Work Shown Below?

The views on this page illustrate how Sauerman Cableway Excavators and Sauerman Power Drag Scrapers have handled different excavating and material-handling tasks and saved their owners money by their economy of operation.

COARSE hard-packed gravel is handled without "shooting" when you put a Sauerman "LeClair" type scraper in the pit, and the cost per cu. yd. excavated and loaded is surprisingly low.

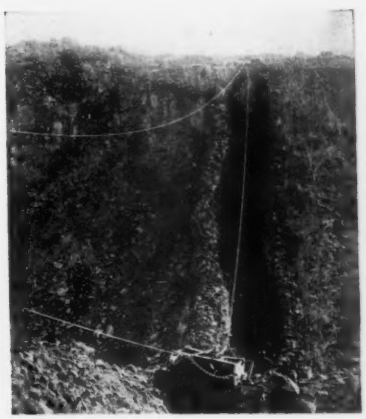
QUARRY conveys and elevates its stone to crushing plant at low cost with a Sauerman Cableway equipped with skips.

COAL can be stored and reclaimed at low cost with a Sauerman "Crescent" Power Scraper, as many power plants have proved.

OVERBURDEN can be stripped from large

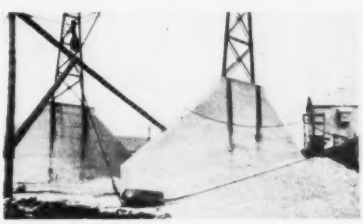
area and deposited in spoil-piles in one operation with a Sauerman Cableway Excavator.

LIGHT excavating and material storage jobs call for an inexpensive machine, and here it is, the Sauerman Portable Power Scraper Outfit.

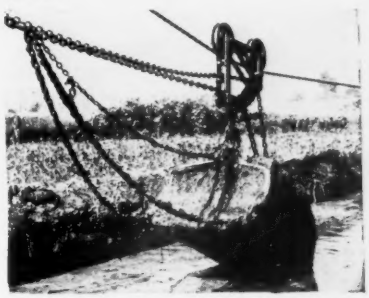


STRIPPING face of quarry with a Sauerman "Excavator" Power Scraper demonstrates this machine's sturdiness and power.

UNDER-WATER material is especially easy to handle with a Sauerman Cableway Excavator and here is a typical 500-ft. span machine in a gravel pit 70 ft. deep.



REHANDLING crushed stone from storage is simplified by using a Sauerman power scraper. The Western Lime & Cement Co. has four installations similar to the above.



CLEANING reservoirs and other excavating work of this kind offers no difficulties if you use a Sauerman Cableway Excavator.

Write to us about *your* problem—

If the illustrations here do not give you sufficient evidence of the adaptability of Sauerman equipment for your conditions and requirements, submit your problem to Sauerman engineers. Their experience, gained through contact with over 1000 installations of Sauerman cableways and power scrapers, is freely at your service. Tell us what you want to accomplish, daily yardage you require and the surrounding conditions and we will suggest the type of equipment and general layout that will give you the desired result at lowest cost.

SAUERMAN BROS., 430 S. Clinton St., CHICAGO

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EVERY OPERATOR who depends upon wire rope for hazardous work and every workman who risks his life with wire rope has a right to demand a more positive evidence as to the grade and make, than the tag on the rope or a mark on the reel

You'll find this protection in

WILLIAMSPORT WIRE ROPE

Not in one grade but all grades

Every foot of Williamsport rope made since November has a patented Telfax tape running clear through the hemp core, which plainly indicates each grade.

For years able engineers who have sensed the dangers from errors and substitution, often at the cost of human lives—have demanded the protection you now get from WILLIAMSPORT.

No concern who sells you wire rope has a right to expect you to take his word for its grade. Human life is too sacred to risk to careless mistakes, so easily made.

WILLIAMSPORT is a Quality product and for years the output of this mammoth plant has been absorbed by operators, whose requirements demanded uniformly high quality. Increased facilities now make available to all this famous rope with Telfax tape protection.

A handsome Telfax Color Chart and a booklet on Modern Wire Rope mailed on request.

WILLIAMSPORT WIRE ROPE COMPANY

Main Office and Works
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The Sign of Efficiency

SILENT CHAIN
THE MORSE "ROCKER JOINT"

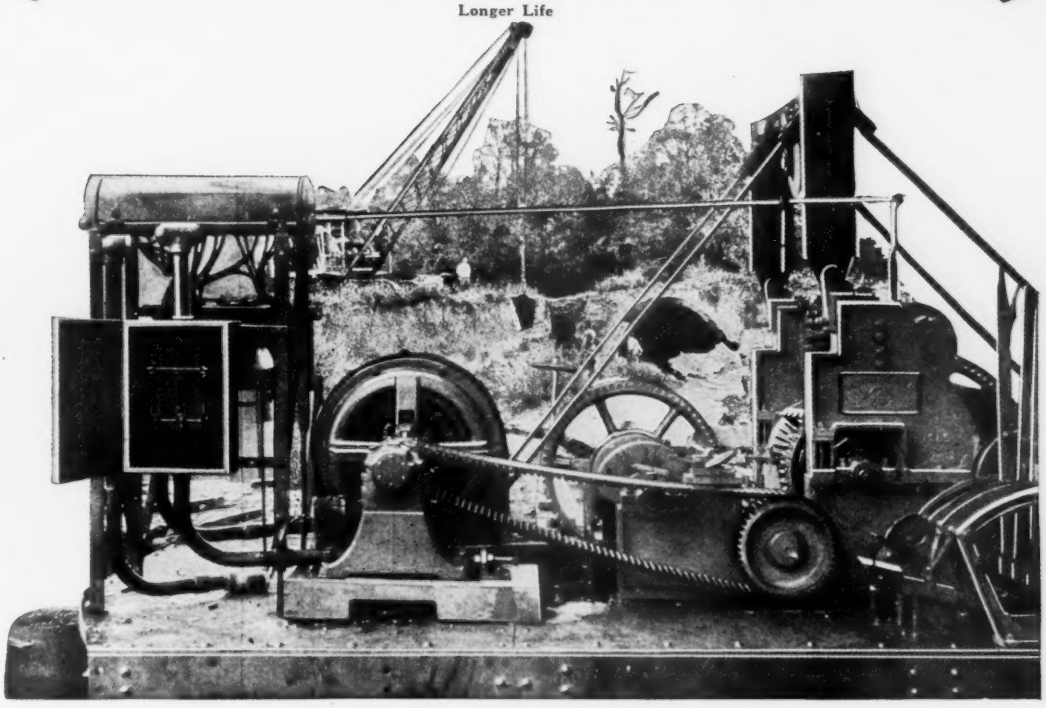
The Sign of Durability

MORSE DRIVES

Positive as Gears

Flexible as a Belt

Longer Life



60 H. P. Applied Direct By Means of

MORSE SILENT CHAIN

The catalog for Byers Full Circle Crane says "..... we aimed for quality first ....."—this photograph shows a No. 10 traction machine on the job with Morse Silent Chain as the power transmission.

Machines of this type get hard wear and the "trouble proof" drive guaranteed by the use of Morse Chains is one of the features that enable them to give constant, efficient service under the most difficult conditions.

Quiet, smooth running, powerful, durable, longer life than gears—a Morse Chain is a safe indication of the *quality* of the service that may be expected from any mechanism on which it is used.

Let Morse engineers cooperate with you to profitably solve your transmission difficulties—ask them.

MORSE CHAIN CO., ITHACA, N. Y.

LARGEST MANUFACTURERS OF SILENT CHAINS IN THE WORLD

MORSE ENGINEERING SERVICE

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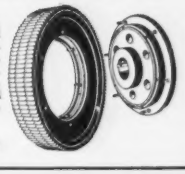
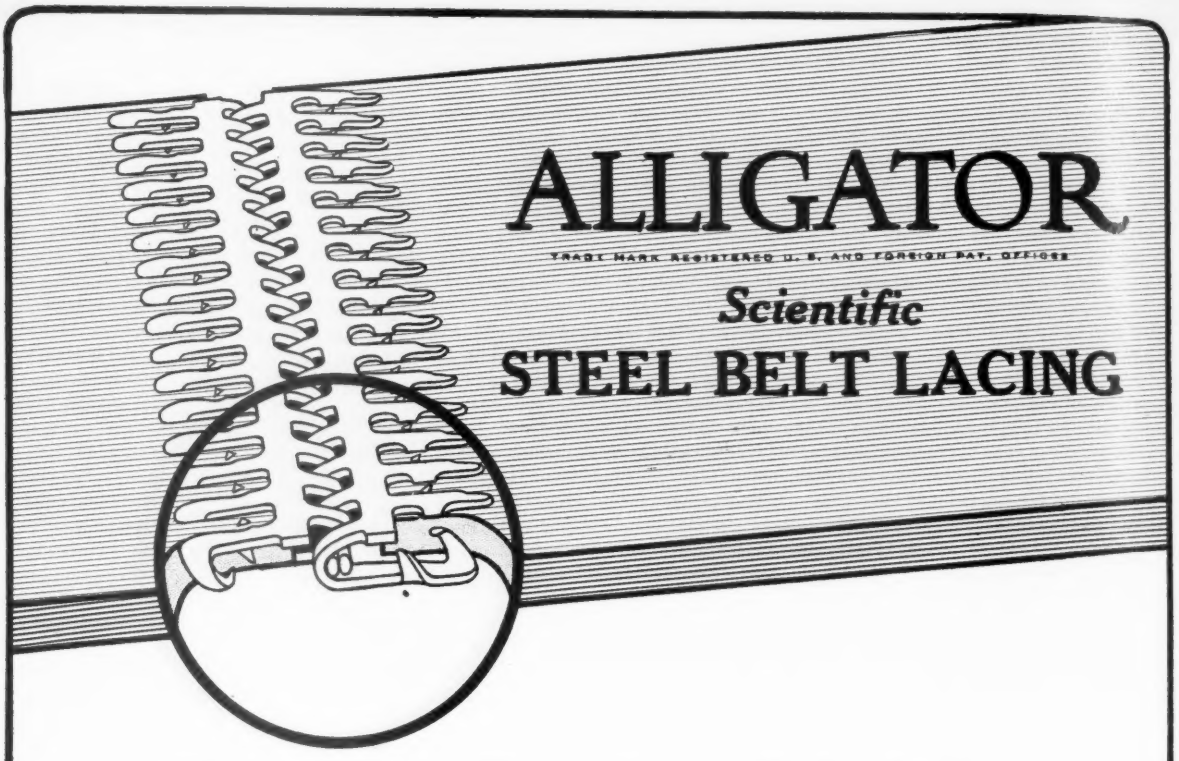


"Morse" is the Guarantee Always Behind the Efficiency, Durability and Service



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TRADE MARK REGISTERED U. S. AND FOREIGN PAT. OFFICES

Scientific STEEL BELT LACING

Know These Two Great Belt Joints

The cost of your lacing or fasteners is nothing as compared to the value of the belt they join—or to the cost of delay in case of their failure. Keep these features in mind when you judge these joints.

Alligator Steel Belt Lacing

makes a hinged joint that is efficient and long lasting for power and conveyor service, smooth on both sides. Note how the teeth clinch over the belt fibres, holding them in equal service and preserving the belt ends. "Every Tooth a Vise." Used on all types and thicknesses of belting up to 5/8 inch. Easily and quickly applied. No tool but a hammer needed—the strongest belt lacing on earth. Standard boxes sold at wholesale and retail the world over. Special lengths for any width of belt supplied quickly at very small increase in cost.

Flexo High Duty Belt Fasteners

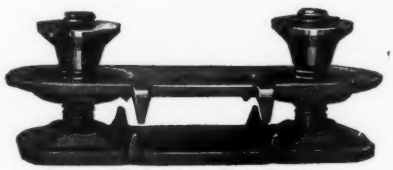
(Compression Type)

make a tight butt joint for conveyor belts. Engineers report that these fasteners beat all previous records in length of service. Now in use on hundreds of conveyors in mine and mill service. In many instances these fasteners have been applied in one-third to one-half time formerly allowed for joining up the conveyor.

Investigate

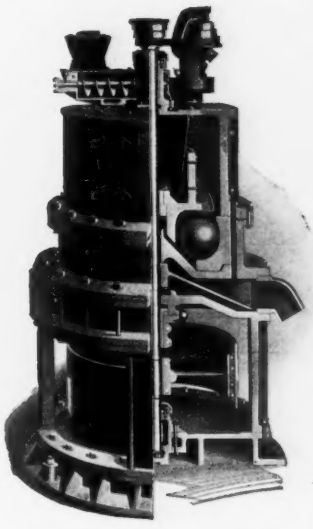
Complete details on Alligator Steel Belt Lacing and Flexco High Duty Belt Fasteners on request, with an interesting "make good" trial offer which many men have accepted with resultant satisfaction.

Flexible Steel Lacing Company
4605 Lexington St., Chicago
In England at 135 Finsbury Pave., London, E. C., 2



Flexco High Duty Belt Fastener

FULLER-LEHIGH PULVERIZER MILL



THE Fuller-Lehigh Pulverizer Mill is unequalled for producing Agricultural Limestone economically.

It will reduce lump rock to 20, 40, 60, 80, 100, 120 mesh, and finer, and requires no outside accessory equipment, no overhead shafts, drives or screens.

All the material discharged from the mill is finished product.

The feeding system is uniform, the discharge is constant and free and the operation is dustless.

Low installation cost. Low operating cost. Low lubricating cost.

Both screen and air separating types built in sizes to meet the requirements of your trade, and will grind rock to meet the specifications of all agricultural experiment stations.

Let Us Send Catalog and Quote on Your Requirements

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Preliminary Mills
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FULLER-LEHIGH CO.

Main Office and Works: FULLERTON, PA., U. S. A.

Crushing Plant Equipment

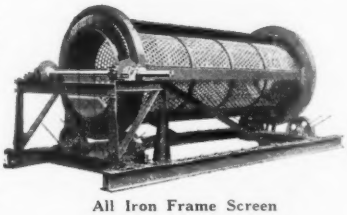
The many crushing plants which have been completely equipped by the Allis-Chalmers Manufacturing Company is evidenced by the satisfactory service which these plants are giving. The Allis-Chalmers Manufacturing Company takes the entire ***responsibility*** for the design of the plant and its equipment. These plants are built on the highest engineering standard following the best engineering practices.

Our Engineers are at your service to make complete installation drawings

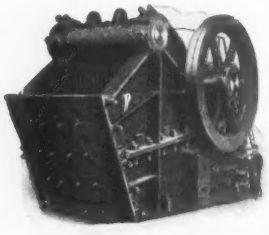
Gates No. 27 Gyratory Crusher, having two openings, each 54 in. x 141 in.

The Gates Style N Crusher, which has been developed in all sizes, is the result of 40 years' accumulated experience of the engineers and designers of the Gates Iron Works and the Allis-Chalmers Mfg. Co.

The durability, simplicity and efficiency of the Gates Patented All-Iron Frame Screens is unequalled by any other screen on the market.



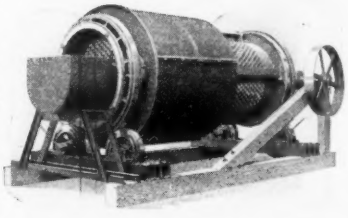
All Iron Frame Screen



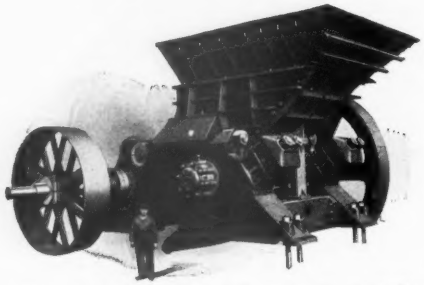
Jaw Crusher

The company has also developed in all sizes Jaw Crushers for crushing copper ore, blast furnace flux and ballast stone.

Gates Screens are built in numerous sizes, ranging from 24-in. diameter by 8 ft. long, to 72 in. diameter by 24 ft. long. Open End Scalping Screens of the Cylindrical type are built in sizes ranging from 48 in. to 72 in. diameter.

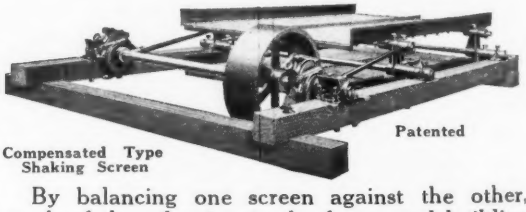


Style "B" Open End Revolving Screen



60 in. x 48 in. Fairmount Type (or Single Roll) Crusher

The Fairmount Crusher is intended to crush limestone, dolomite, phosphate rock, magnesite and other less tenacious rocks. It is not suitable for, nor do we recommend it for granites, trap rock or other igneous rock.



Patented

Compensated Type Shaking Screen

By balancing one screen against the other, much of the vibration in the frame and building is eliminated. Up-to-date commercial limestone and gravel plants realize the vital importance of installing shaking screens, permitting the production of smaller stones to meet the market requirements.

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Power Transmission Machinery
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Air Compressors - Air Brakes
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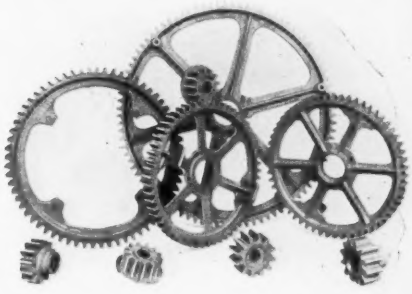

WE MANUFACTURE

Manganese Steel Sheaves for

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- Cranes
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- Sprockets
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- Fronts of the Plain and Vanderhoef Type
- Teeth of the Solid and Two-Part Type
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- Dipper Lips and Bottoms
- Shipper Shaft Pinions and Racks
- Bails, Bail Brackets, Clevises and Lugs
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- Propelling Gears
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- Crawler Track Shoes
- Dolly Wheels (Trunnions or Rollers)
- Hinges
- Rail Clamps
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AMSCO Pumps

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- Pipe
- Pipe Flanges
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- Clamshell Bucket Lips
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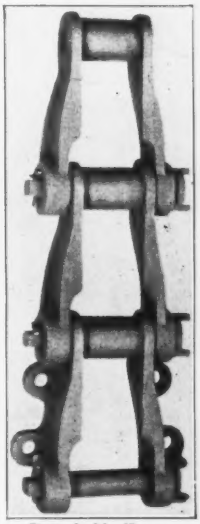
AMSCO

Manganese Steel PRODUCTS

The profits earned by your equipment are the sole basis of judging its worth to you.

The introduction of AMSCO products to your plant means less repairs, fewer overhauls, less time lost for shut-downs, and economy in a multitude of different ways. For quarry operations the Missabe Manganese Steel Dipper Equipment with Clark Reversible points, fronts of the plain and Vanderhoef type will give you a service performance unequalled in value.

AMSCO Manganese Steel Products from the top to the bottom of the list are built to stand extremely hard service.



Detachable Type

American Manganese Steel Co.

General Sales Office:

398 East 14th Street, Chicago Heights, Ill.

FOUNDRIES:

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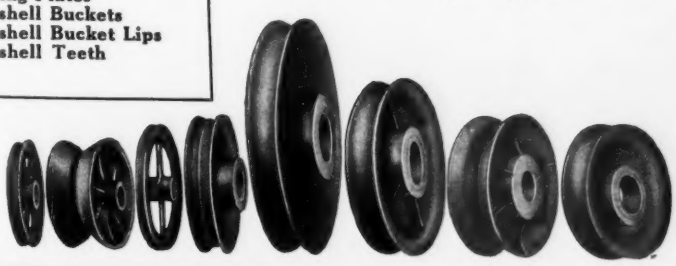
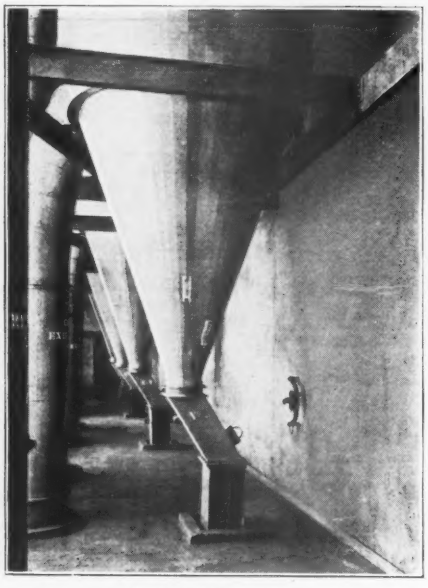
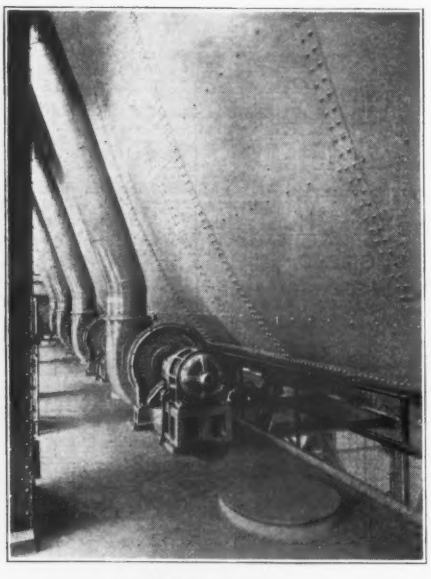




Cyclone Collectors



Special Exhaust Fans

The above views show parts of the Eight Mill Powdered Coal Installation at the boiler plant of the Ford Motor Co., Detroit

The Record of Raymond Roller Mills Grinding Coal in This Plant Speaks for Itself

Initial four Mills installed July, 1920.

Two added June, 1922.

Two more added January, 1923.

And—Two more will be installed in a Cement Plant being built by this Company now.

Raymond Roller Mills for powdering Coal require less power, less maintenance and less labor attendance than any other machines ever used for this purpose.

Raymond Bros. Impact Pulverizer Co.

1301 N. BRANCH ST. CHICAGO, ILL.

Eastern Office, 50 Church St., NEW YORK CITY
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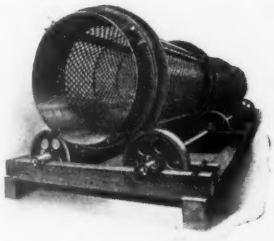
CHAMPION CRUSHERS



Our roller driven type of Champion Revolving Screen for heavy duty. Made in diameters of 40 in., 51 in. and 60 in. to any length.

All our screens are made of best material, giving them a reputation for durability and economy in operation.

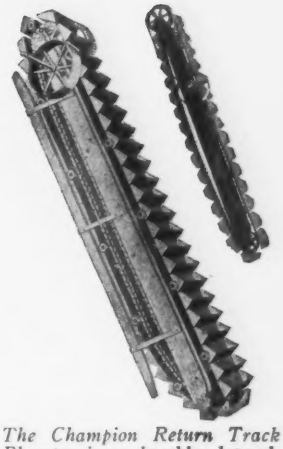
Champion Crushers represent the cumulative results of years of careful thought and study, and of exhaustive experimenting with all past and present type of crushing equipment.

These crushers have been developed to a point where they are not only conceded to be convenient, durable and serviceable, but where in all cases they meet in the best possible way the individual requirements of the user.

We have every engineering and factory facility for building high-class quarry and sand and gravel equipment, and we solicit inquiries from all who are interested in the economical production of non-metallic minerals.

We design, build and install complete crushing equipment of any size desired. We specialize in the building of elevators, screens, and conveyors of any desired capacity.

Ask for catalog, "Champion Crushing and Quarrying Machinery." It is free.

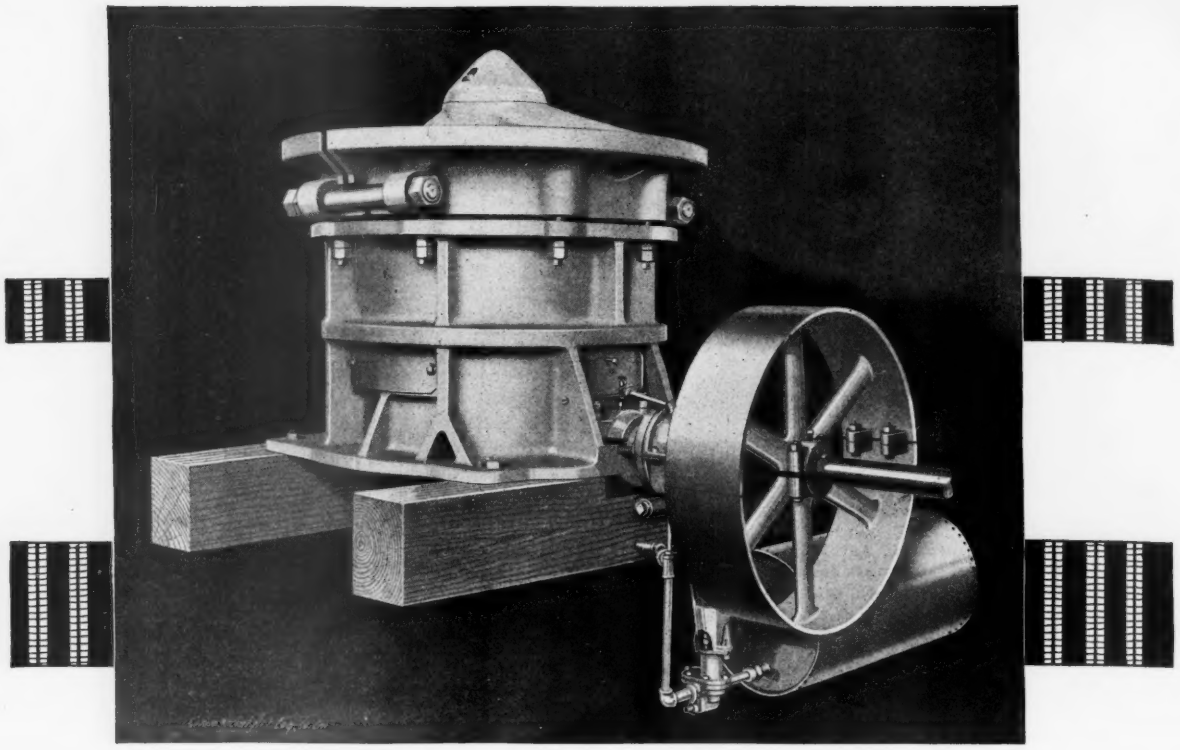


The Champion Return Track Elevator is so durable, dependable and steady in operation that users of crushers other than the Champion have formed the habit of specifying the Champion Elevator when it is necessary for them to install machinery of this kind.

The Good Roads Machinery Co., Inc.

Kennett Square, Pa.

1203 Tower Building, Chicago, Illinois



TELSMITH

THE CAST STEEL

BREAKER

Why not insure your crusher against breakage by tramp iron? You insure your house against fire. Most men carry life insurance. A majority insure themselves against physical injury. For the same reasons, we recommend that your crushing plant be insured against breakdown. Put in Telsmith—the crusher of **steel**—twice as strong as grey iron crushers. Frame, crown and shaft—the vital parts of the machine—are all proof against breakage, even by tramp iron. Telsmith insures you against expensive shutdowns, idle crews, suspended production, loss of prestige, disappointed customers. This insurance costs you only a very small sum—the difference between the cost of steel and grey iron—and it SURE IS WORTH THE PRICE.

We have some new catalogs—just off the press—chock full of information. Send for catalog No. 166 (Telsmith Primary Breaker) and bulletin No. 2F11 (Telsmith Reduction Crusher). No obligation.

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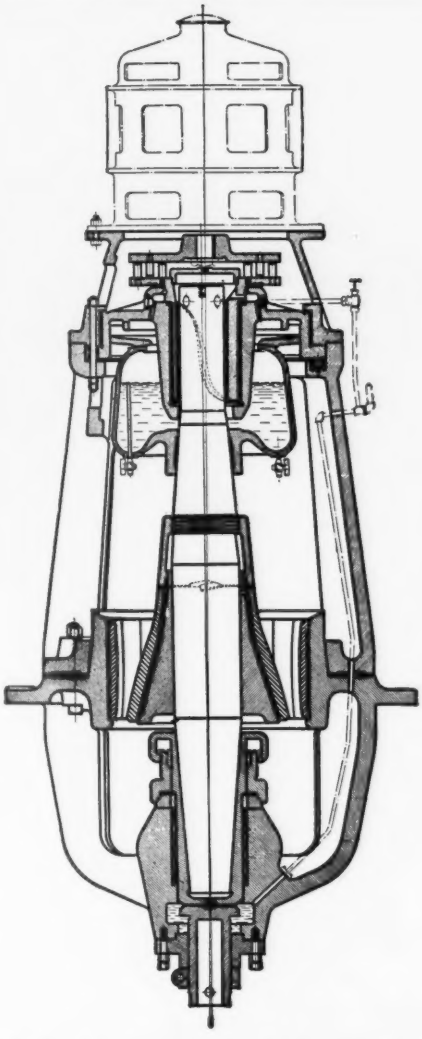
The Weston Direct Drive Gyratory Crusher for Secondary Reduction of Hard Rock, Ore and Gravel



Developed In a Granite Crushing Plant

1. Capacity is 3 to 5 times greater than geared gyratories with less power consumption in proportion. Speed of gyrations 3 to 4 times higher than geared crushers, making it possible to crush a rock and its parts four times as it falls through. Finishes 90% of rejects on closing side.
2. Gears, Countershafts and Belts are eliminated. Eccentric is at the top, is Bronze Bushed and Oil Floated.
3. Entrance of dust into oil supply and bearings is absolutely prevented. Lubrication is positive without pumps. Accurate tests on No. 36-A shows a gallon of oil per minute flowing through main eccentric bearing.
4. All parts accessible to overhead crane. Crushers may be completely dismantled or assembled in one hour.
5. Construction is all steel with Chrome-Vanadium Molybdenum forged steel shaft.

Built in six standard sizes—largest size takes 12″ rock rejecting 350-450 tons per hour. Smallest machine when set to 1¾″ rejects 120 tons per hour, or 40 tons per hour with ½″ setting. Arranged for both motor and belt drive.

Send for Bulletin 25 Which Describes This Machine in Detail

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Designers, Manufacturers and Contractors
Electric Traveling Cranes, Rolling Mill Machinery
Ordnance, Steel, Shipbuilding and Forging Plants Complete,
Rock Crushers, Special Machinery for Any Purpose

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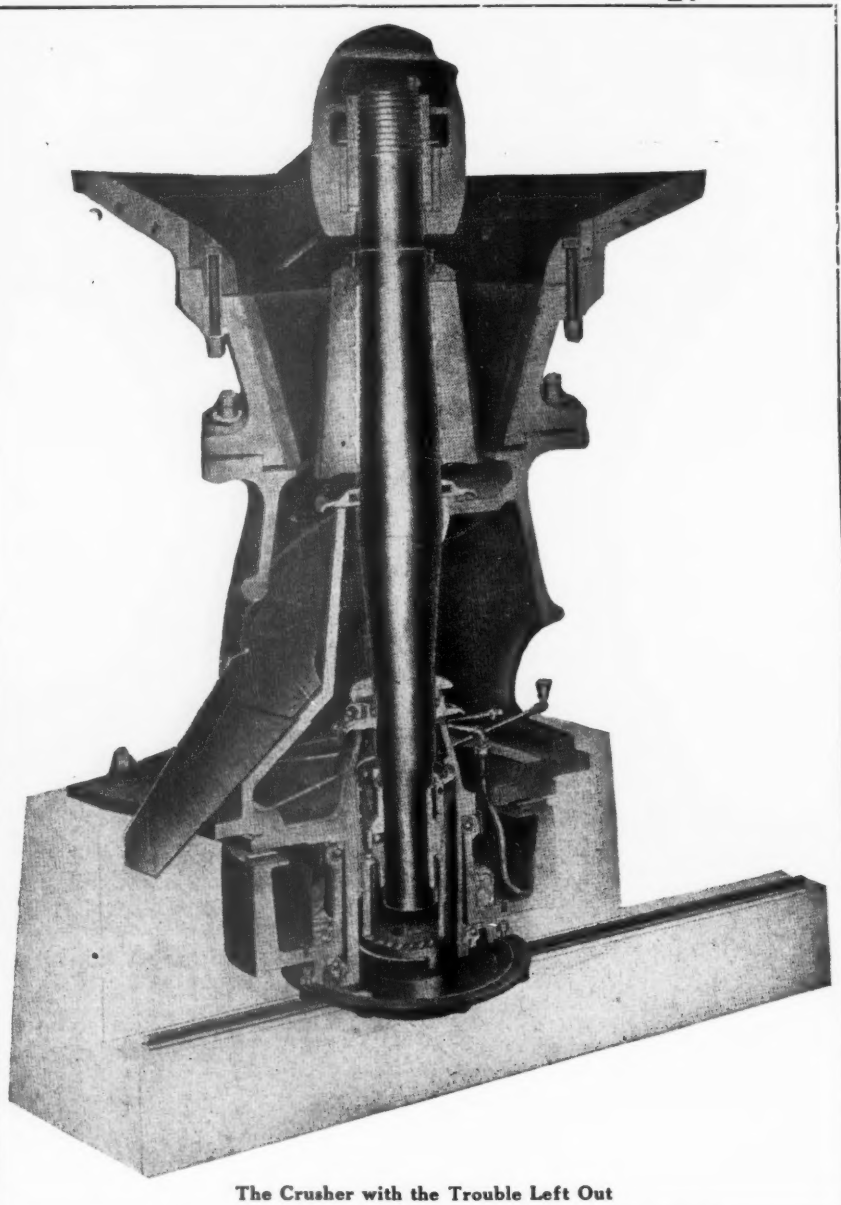
KENNEDY *GEARLESS* CRUSHERS

The Kennedy has revolutionized the rock crushing industry. It represents a definite step in advance, and is unquestionably the best, strongest, and most efficient unit known to rock crushing engineering.



The Crusher with the Trouble Left Out

Points of Superiority

1. Less Power Consumption
2. Low Operating Cost
3. Continual Operation —Not Limited to Safe Gear Speed — Strikes a Harder Blow, and Has Increased Capacity
4. Perfected Dust Proof Circulating Oiling System.
5. Can Be Set in Any Position—And Takes Less Room
6. Equipped with Patented Ball and Socket Eccentric.
7. Noiseless.

Parts Eliminated

1. Outboard Bearing
2. Counter Shaft
3. Inner Bearing Cap
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5. Thrust Ring
6. Pinion
7. Gear
8. Key for Gear
9. Two Steel Wearing Rings
10. Bronze Wearing Rings.

Parts Added

1. Set Balls
2. Ball Race Rings
3. Ball Retainer.

This improvement has actually reduced cost of maintenance 80%, not including head and concaves.

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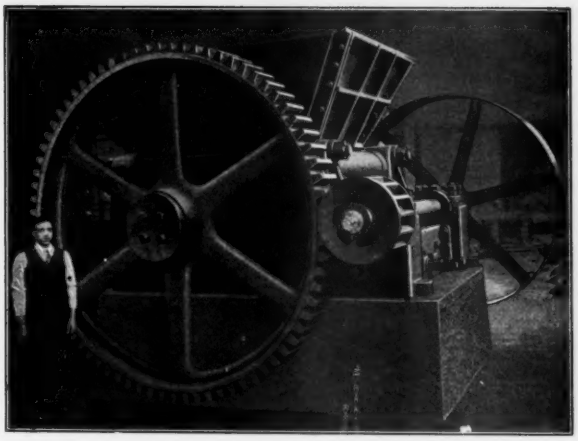

If- you are looking for a crushing service that meets emergencies and reduces costs, if you want to cut the idle time of men and equipment to a minimum, if you want to cast aside the great number of annoyances and troubles that continually beset the operator of a gyrating or jaw crusher, install

Mc Lanahan Crushers

The McLanahan is a single roll crusher. It is the result of many years' practical experience building and operating other types of crushers, and time has proven it to be the best, simplest and most economical crusher yet developed. It makes less fines, requires but little head room, no apron or hand feeding and will take wet or slimy material.

Capacity 5 to 500 tons per hour. For any material not harder than hard limestone and not exceptionally high in silica

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Hollidaysburg, Pa.
Screens, Elevators, Conveyors, Rock Washers, Etc.

Manufacturers of Quarry Machinery, Equipment and Supplies!

JOIN

THE MANUFACTURERS' DIVISION OF THE NATIONAL CRUSHED STONE ASSOCIATION

BECAUSE

IT WILL help you in your business with quarry owners and operators, and you can help them in solving some of the problems of a big, basic industry.

The objects of the Manufacturers' Division of the National Crushed Stone Association are:

A. To bring the manufacturers of machinery, equipment and materials used in the quarrying and the production of crushed stone into closer and more intimate contact with the quarry operators and producers of crushed stone.

B. To co-operate with the quarry operators and producers of crushed stone in the solution of the technical problems pertaining to quarry and crushing plant design and operation.

C. To co-operate with the officers and committees of the National Crushed Stone Association in making the annual conventions of the industry of the utmost educational value.

D. To present to the quarry industry at its annual convention, the new developments in machinery, equipment and materials, and to lay before the industry information and data of value, which has been collected and compiled by the machinery, equipment and materials manufacturers.

E. To provide, if possible, for an exhibit of quarry and crushing plant machinery, equipment and materials or models of machinery and equipment at the annual convention of the industry.

F. To co-operate in any other way that the members of this division and the officers and directors of the National Crushed Stone Association may deem advisable.

Associate Membership Application

NATIONAL CRUSHED STONE ASSOCIATION

Headquarters, 405 Hartman Bldg., Columbus, Ohio

Date.....

Application is hereby made for associate membership, at $50.00 per annum, in the

NATIONAL CRUSHED STONE ASSOCIATION

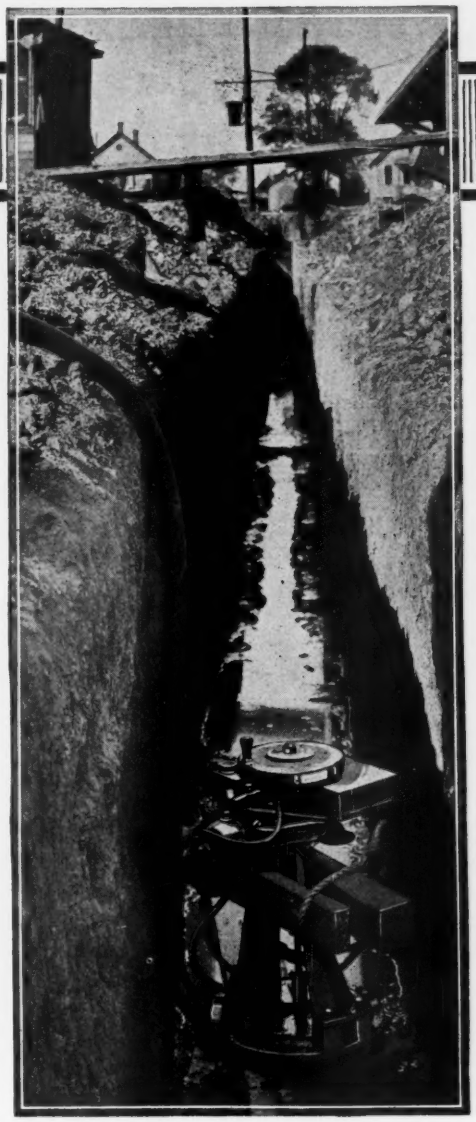
it being understood that this amount is the total of my financial obligation in and to the National Crushed Stone Association for the year 192.....

(Signed).....
(Company)

Office Address:

..... By .....

A "FORD" in the Pump Field



In Close Quarters

JOBS that stump heavier, more cumbersome pumps are easy for the Evinrude Centrifugal. You can lower an Evinrude into ditch, caisson or excavation and submerge the pump into the water. No "installation" needed. Works with or without a suction line. Pumps 5000 gallons an hour at a 20 ft. head.

The Evinrude Centrifugal Pump is right at home on a score of jobs. Disposes of drainage water in quarries, gravel pits and mines. Empties coffer dams for bridge builders. Supplies road builders with water for their mixers. Clears rain water out of contractors' building excavations. Drains ditches for sewer contractors. Aids street railway and public service companies in their underground work. Used by fire departments for pumping flooded basements. Ideal priming outfit for sand dredge pumps.

If you need a pump of the Evinrude capacity send today for illustrated literature describing Evinrude features and uses.

DEALERS: The coming of Spring doubles your Evinrude Pump prospects. Desirable territory still available. Write today for our proposition.

EVINRUDE MOTOR COMPANY
43 Lake Street Milwaukee, Wis.

The Evinrude Centrifugal Pump consists of the pump proper and a built-in 2 H.P. gasoline engine—the same power plant now used in 150,000 Evinrude Rowboat Motors. Weighs only 115 lbs. Easily moved by one or two men.

5000 GALLONS per hour at 20 ft. head

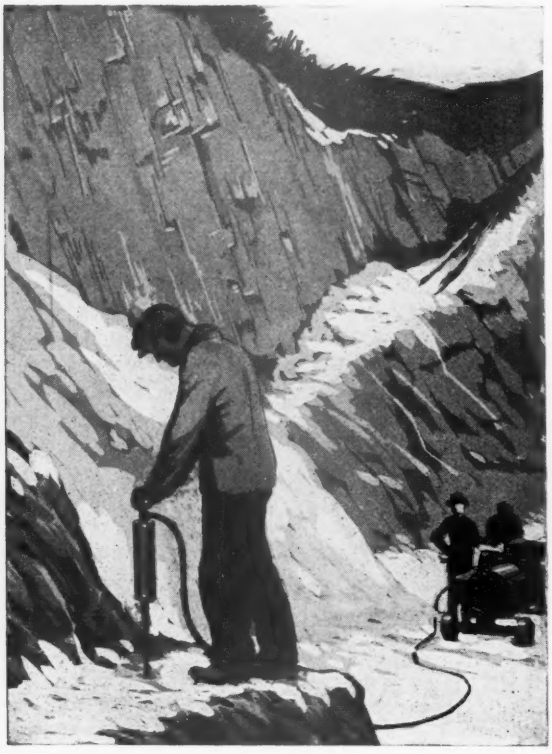
EVINRUDE CENTRIFUGAL PUMP

For users requiring a more powerful pump the Evinrude No. 1½ is recommended. 7400 gallons per hour at a 20-ft. head —3½ h.p. Evinrude motor. Price $175.

Price: $150.00 F.O.B. MILWAUKEE

When writing advertisers please mention ROCK PRODUCTS

ATLAS
EXPLOSIVES
for quarrying



IN practically every kind of quarry blasting Atlas Ammite will do better work—and at less cost. Furthermore, as Ammite will not freeze and the usual powder headache is eliminated when handling, its use saves the time and labor lost through these objectionable features. Let the Atlas Service Man help you determine what grade of Ammite will save the most money for you.

AMMITE
—cannot freeze—

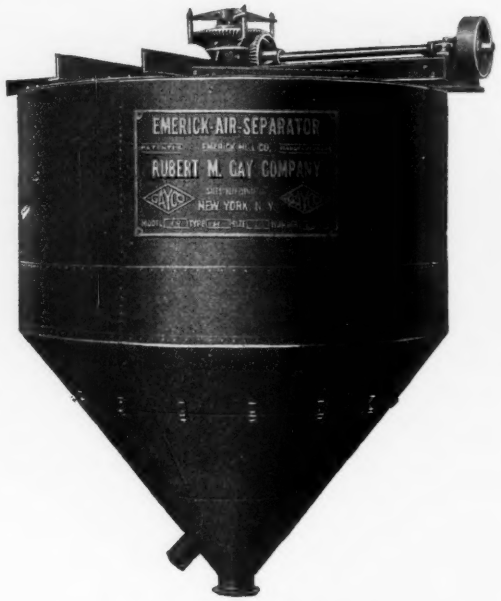
ATLAS POWDER COMPANY
WILMINGTON, DELAWARE

Branch Offices:
Allentown, Pa.; Birmingham, Ala.; Boston, Mass.; Charleston, W. Va.; Chicago, Ill.; Des Moines, Iowa; Houghton, Mich.; Joplin, Mo.; Kansas City, Mo.; Knoxville, Tenn.; McAlester, Okla.; New Orleans, La.; New York City, N. Y.; Norristown, Pa.; Philadelphia, Pa.; Pittsburg, Kans.; Pittsburgh, Pa.; Pottsville, Pa.; St. Louis, Mo.; Wilkes-Barre, Pa.

ATLAS EXPLOSIVES

THE GAYCO EMERICK

Centrifugal Air-Separator



A Dependable "AIR-SCREEN" for sizing Fibrous, Flaky or Granular Materials

60 Mesh to 350 Mesh

The Only Air-Separator for fine ABRASIVE PRODUCTS

RUBERT M. GAY COMPANY
114 Liberty St., New York, N. Y.

CLASS OF SERVICE	SYMBOL
Telegram	
Day Letter	Blue
Night Message	Nite
Night Letter	N L

If none of these three symbols appears after the check (number of words) this is a telegram. Otherwise its character is indicated by the symbol appearing after the check.

WESTERN UNION TELEGRAM

NEWCOMB CARLTON, PRESIDENT GEORGE W. E. ATKINS, FIRST VICE-PRESIDENT

CLASS OF SERVICE	SYMBOL
Telegram	
Day Letter	Blue
Night Message	Nite
Night Letter	N L

If none of these three symbols appears after the check (number of words) this is a telegram. Otherwise its character is indicated by the symbol appearing after the check.

XB M 1215 P

SUPERINTENDENT

BELT USING COMPANIES

EVERYWHERE

TO GET "ENDLESS" BELTING RESULTS AT SMALL FRACTION OF ENDLESS COST USE "CRESCENT BELT FASTENERS" ON YOUR OPEN DRIVES STOP WRITE FOR FULL TECHNICAL DATA

SIGNED CRESCENT BELT FASTENER CO.

NEW YORK

#ANS DH TO 381 FOURTH AVE NY

"CARROLL" SOLID WELD CHAINS

SERVICE AT THE BUFFALO SLAG CO.

The Carroll principle of omitting nothing which contributes to a faultless chain accounts for the fact that every user soon becomes an enthusiastic booster. Read what Mr. H. E. Rainer writes:

"The 1¼-in. Steam Shovel Hoisting Chain which we purchased from the Carroll Chain Company of Columbus, Ohio, early last season for one of our Model 61 Marion Steam Shovels has proved entirely satisfactory.

"We believe that Mr. Carroll makes one of the best steam shovel chains that can be purchased anywhere."

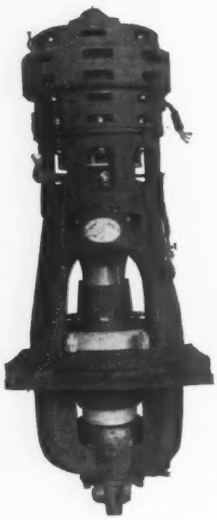
Very truly yours,
The Buffalo Slag Company,
By H. E. Rainer.

This is the opinion of experience.

THE CARROLL CHAIN CO.

Columbus, Ohio

The New Weston Direct Drive Gyratory Crusher for Secondary Reduction of Hard Rock, Ore and Gravel



A BETTER CRUSHER BECAUSE

Gears, Countershafts and Belts are eliminated. Eccentric is at the top, is Bronze Bushed and oil floated.

Entrance of dust into oil supply and bearings is absolutely prevented.

By removing six bolts—machine can be taken apart with crane or derrick.

Capacity is 3 to 5 times greater than geared gyratories.

Power consumption is exceptionally low.

Construction is all steel with Chrome-Vanadium Molybdenum forged steel shaft.

Built in six standard sizes—largest size takes 12-inch rock rejecting 350-450 tons per hour. Smallest machine when set to 1¾ inches rejects 120 tons per hour, or 40 tons per hour with ½-inch setting.

Send for Bulletin 25 Which Describes This Machine in Detail

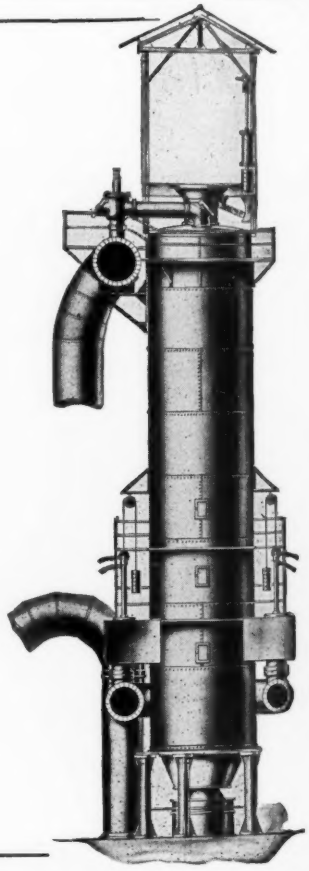
THE MORGAN ENGINEERING COMPANY
ALLIANCE, OHIO

Pittsburgh
1420 Oliver Bldg.

Designers, Manufacturers and Contractors
Electric Traveling Cranes, Rolling Mill Machinery
Ordance, Steel, Shipbuilding and Forging Plants Complete
Rock Crushers, Special Machinery for Any Purpose

Chicago
122 S. Michigan Ave.
Birmingham, Ala.
Brown-Marx Bldg.

Continuous Discharge—Gas Fired
LIME KILNS



The wastefulness of efficiency of any lime burning apparatus is determined by the amount of fuel per ton of lime produced.

Our Kilns are not an experiment, but have successfully met the test of years of actual service. The design is the work of our Consulting Mechanical and Chemical Engineer, who has had many years of practical operative experience. They embody a number of labor saving devices, and are designed to secure maximum production with minimum fuel consumption; their record in this respect should interest every lime producer in the country.

Glamorgan Pipe & Foundry Company
Lynchburg, Va., U. S. A.

Using the Nationally Famous Virginia Foundry Irons

SULLIVAN ROTATORS

Hard on the rock—
Easy on the runner

DO YOU need drills this spring?

Why not buy Sullivan Rotators?

Their drilling speed, air and repair economy and convenience are guarantees of high production and low cost.

For block holing **use Rotators.**

For shallow holes in trenches **use Rotators.**

For deep holes on benches **use Rotators.**

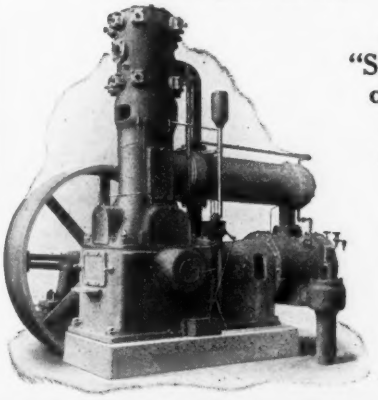
For any drilling in road grading **use Rotators.**

For light tripod or quarry bar drilling **use Rotators.**

Rotators weigh 38 lbs., drill holes to 14 feet readily, and may be had in seven models to suit the work to be done. **Bulletin 2481A**

Air compressors

Large or small, stationary or portable,



there's a "SULLIVAN" of the type and size you need

Ask for information on this Angle-Compound belted Compressor, 450-3500 cu. ft.

Bulletin 2477-B

SULLIVAN MACHINERY COMPANY
82 EAST ADAMS STREET CHICAGO, ILLINOIS, U.S.A.

DOMESTIC SALES OFFICES:
Birmingham, Boston, Butte, Claremont, N. H., Cleveland, Dallas, Denver, Duluth, El Paso, Huntington, W. Va., Joplin, Juneau, Knoxville, New York, Pittsburgh, St. Louis, Salt Lake, San Francisco, Spokane.

FOREIGN SALES OFFICES:
Algiers, Brussels, Calcutta, Christiania, Durban, Natal, Havana, Lisbon, London, Madrid, Mexico City, Paris, San Juan, Santiago, Shanghai, Sydney, N. S. W., Tokyo, Toronto, Tunis, Turin, Vancouver.

Air Compressors; Air Lift Pumps; Diamond Drills; All-Hammer Drill Sharpeners; Drill Steel Furnaces; Forge Hammers; Ironclad Coal Cutters; Rock and Hammer Drills; Quarrying Machinery.

Products for the Sand, Gravel, Stone, Cement, Gypsum and Lime Industries

Transmission Belting
Conveyor and Elevator Belting
Sand Suction Hose and Dredge Sleeves
Air Hose
Sheet Packings, both Rubber and Fibre
Steam Hose
Water Hose
Piston Packings of all kinds
Pump Valves

OUR PACEMAKER Transmission Belting is made of especially woven heavy duck impregnated with a pure gum friction or bond between the plies and is designed for very severe service, such as crushers, etc.

ARNO CONVEYOR BELTING—made of heavy duck with a high grade friction between the plies and an exceedingly tough, fibrous cover to withstand the abrasive effect of sand, gravel, crushed rock, etc.

HONTAS CONVEYOR BELTING—made of the same duck as Arno, with a very good cover and especially recommended for clay, dirt and other materials not requiring as high grade a cover as Arno.

SANDOW Sand Suction Hose and Arno Dredge Sleeves are too well known in this industry to require very elaborate details of construction. They are both made extra heavy and oversize for the entire length, thereby eliminating the weakness of enlarged ends.

LOSANT AIR DRILL HOSE is unquestionably the highest grade hose manufactured for this exacting service.

We manufacture Water Hose and Steam Hose of exceptionally high quality to suit the most severe service.

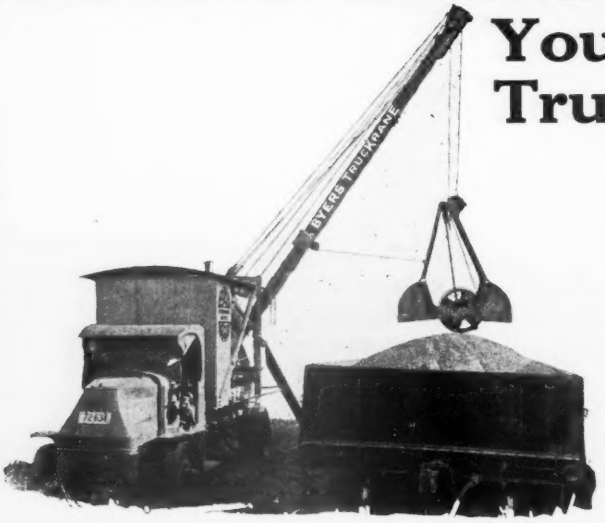
Sheet Packings and Piston Packings of all styles.

Pump Valves for high and low pressure, hot and cold water.

Prices and samples gladly furnished on request

The Cincinnati Rubber Mfg. Co.

Cincinnati, Ohio



You Own Half a TrucKrane, Already

THAT old 5-ton truck that you were going to trade in for a new one—it would make an ideal mounting for a Truckrane. All that's necessary is that the chassis be 9' 6" from the rear of the driver's seat to the center of the rear axle.

We furnish the crane part brand new and that's all you have to pay for to own a complete Truckrane unit—less than the price of a new truck alone.

The Truckrane is crane and motor truck combined. Within its capacity, it can handle crushed stone and rock as capably as a bigger machine and its increased movability makes it much easier to shift from one job to another.

Get acquainted with the complete Byers line of Cranes —Full Circle, Auto-Crane (half circle) and Byers Truckranes. In use by contractors and quarry men all over the country.

BYERS AUTO-CRANE AND REVOLVING TYPES CRANES

THE BYERS MACHINE COMPANY

310 Sycamore Street, Ravenna, Ohio

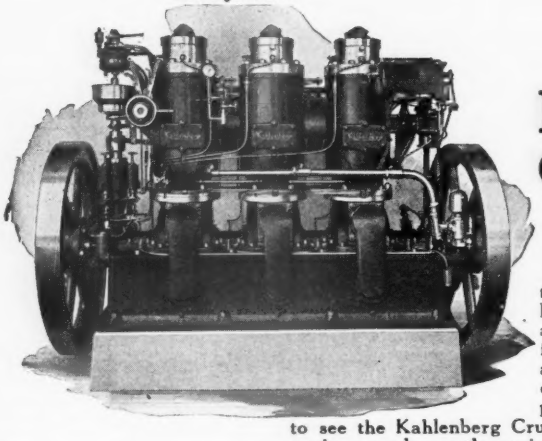
New York Chicago Pittsburgh St. Louis

Sales Representatives in All Other Principal Cities

Builders of Full Circle Cranes (7 tons); Standard "Auto-Cranes" (5 tons); "Auto-Cranes" Model "1" (2½ tons); Buckets; Hoists (Steam, Gasoline, Electric, and Belt), etc.

TrucKranE

"Kahlenberg Engines Give Satisfaction Everywhere"



Kahlenberg

HEAVY DUTY OIL ENGINES

Sizes 25 to 180 H.P.

News of the New Kahlenberg Crude Oil Engine has spread throughout the Stationary Engine Industry. It did not take long for alert men in every corner of the land to learn that a radical and original engine improvement has been brought forth. Men who have seen the new type Kahlenberg in action have told others—all have agreed that no other crude oil engine has embodied the original features conceived and perfected by Kahlenberg. For this reason, we want you also to see the Kahlenberg Crude Oil Engine, note its convenience and smoothness in action, when running at any speed, no load, or full load. Note particularly that it idles all day without skipping and takes up full load without shock or jar instantly, and without special devices of any kind—it is built that way.

Note these original features:

Patented—Governor control.
Patented—Injection control.
Patented—Air starting and reversing.
Patented—Water cooled combustion chamber.
Patented—Pressure fuel oil strainer.
Every part "getatable" and removable.
Guaranteed to operate perfectly on any of the crude fuel oils or kerosene.

May we send you a catalogue?

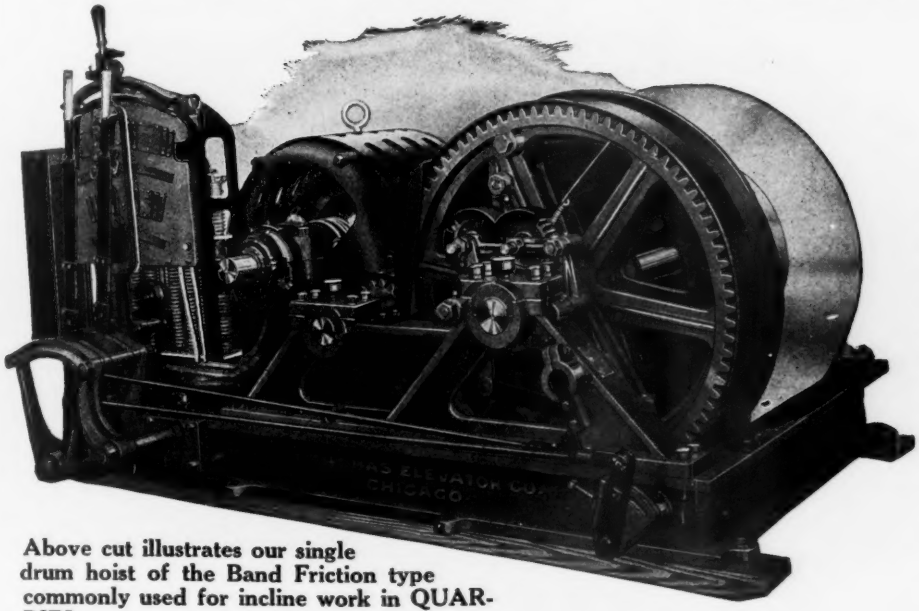
KAHLENBERG BROS. CO.

Manufacturers

1720 12th St., Two Rivers, Wis., U. S. A.

Kahlenberg engines are very simple and easily operated by any man of ordinary intelligence — no valves to regulate, no high pressure air — automatic regulation and lubrication throughout.

THOMAS HOISTS



THOMAS

single and two-speed types built for Dragline Cableways, Drag Scrapers, Derricks, Bucket Operation, Car Haulage.

Above cut illustrates our single drum hoist of the Band Friction type commonly used for incline work in QUARRIES

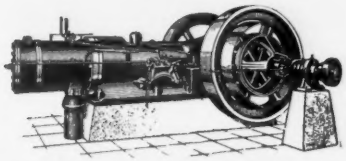
THOMAS ELEVATOR COMPANY, 27 So. Hoyne Ave., Chicago, Ill.

POWER TALKS ~ ~ NO. 2.

Time Out!

Day in and day out over a period of years, "PRIMM" Oil Engines have been delivering steady, dependable power. A "PRIMM" never requires "time out"—no shut downs. "PRIMM" Oil Engines are built to last—to give continuous service — always. This is one of the many reasons why they cut power costs everywhere.

Find out more about this economical, reliable Oil Engine today. Interesting literature will be mailed to you upon request.



Built in sizes from 20 to 300 H. P. to meet any power requirement.

PRIMM OIL ENGINES

The Power Manufacturing Co.

705 Cheney Ave., Marion, Ohio

Builders of Reliable Oil Engines for Twenty Years

"Service Built In At The Factory and Maintained In The Field"

A Few of Our Clients

Cement Plants

Chicago Portland Cement Co.
German American Portland Cement Co.
Ironton Portland Cement Co.
Petoskey Portland Cement Co.
Pittsburgh Plate Glass Co.

Rock Crushing Plants

Dolese & Shepard Co.
Chicago Union Lime Works
Brownell Improvement Co.
Canada Crushed Stone Corp., Ltd. (2 plants)
Montreal Crushed Stone Co., Ltd.
Dunbar Stone Company
Illinois Steel Company

Railroad Ballast Plants

Grand Trunk Railway System
Vandalia Railroad Co.
Virginian Railway Co.

Gravel Plants

Chicago Gravel Co. (3 plants)
Lake Shore Sand Co.
Battjes Fuel & Bldg. Material Co.
Niles Sand, Gravel & Rock Co.
Northern Gravel Co.
Akron Sand & Gravel Co.

Industrial Plants

Havana Metal Wheel Co. (3 jobs)
Crescent Forge and Shovel Co.
Great Cobar, Ltd. (Australia)
Stephens Adamson Mfg. Co.

Power Stations

Brownell Improvement Co.
Petoskey Portland Cement Co.
Rockford Drop Forge Co.
Hyde Park Hotel

J. C. BUCKBEE COMPANY, ENGINEERS

1733 First National Bank Building, Chicago, Ill.

WELLER-MADE EQUIPMENT

For Handling the Materials Mechanically

Increase the Output and Reduce Costs by Employing Weller-Made Machinery to Do the Work

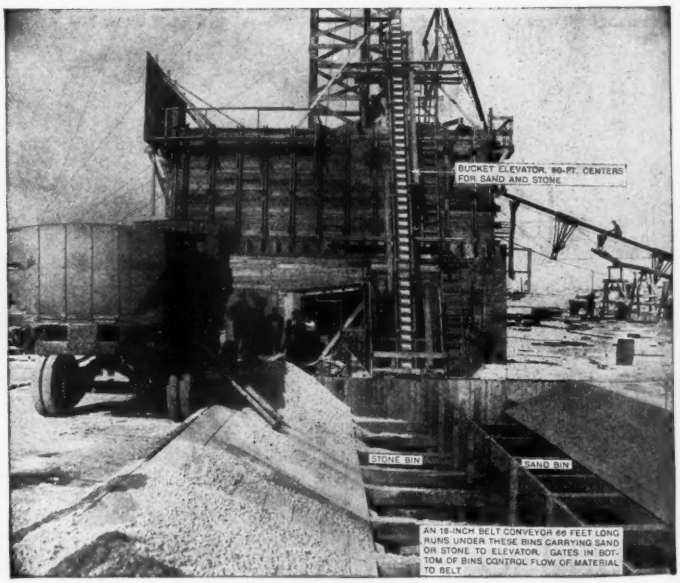
It is sturdy and reliable. Never lays down on the job. The cost of operation is small. Will help pay dividends.

We Make
Conveyors of All Types

Bucket Elevators	**Portable Elevators**
Steel Storage Bins	**Bin Gates**
Screens	**Sheet Metalwork, etc.**

WELLER MADE CHICAGO

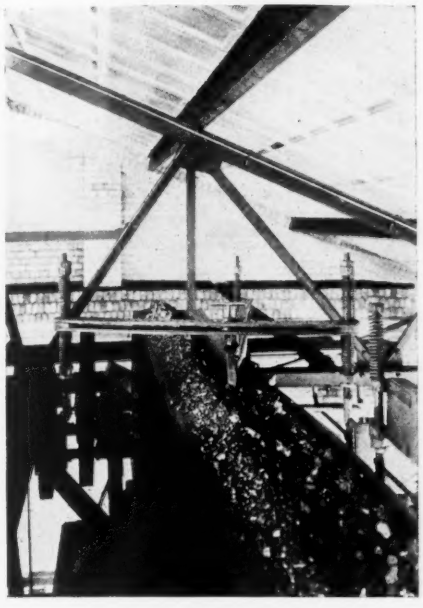
Write and let us know the kind of equipment you are interested in or the material you want to handle. Catalogues showing installations, also data to help in selection of equipment, will be sent.


BUCKET ELEVATOR, 90-FT. CENTERS FOR SAND AND STONE
STONE BIN
SAND BIN
AN 18-INCH BELT CONVEYOR 66 FEET LONG RUNS UNDER THESE BINS CARRYING SAND OR STONE TO ELEVATOR. GATES IN BOTTOM OF BINS CONTROL FLOW OF MATERIAL TO BELT

WELLER MFG. CO.

1820-1856 North Kostner Avenue **SALES OFFICES** **Chicago, Illinois**

New York **Boston** **Baltimore** **Pittsburgh** **Cleveland** **San Francisco** **Salt Lake City**



SANDVIK
Steel Belt Conveyor

Sandvik Steel Conveyor Belts are made of high grade Swedish Charcoal Steel by a special process—cold rolled, hardened and tempered in one piece lengths up to 350 ft. They are of a self-supporting nature, requiring fewer supports—are absolutely smooth running, and have **a simple discharge arrangement,** replacing present expensive and cumbersome trippers used in rubber belt practice, consisting of a scraper plow which removes either full or part of the load.

The photograph at the left shows a scraper in operation, discharging part of the load.

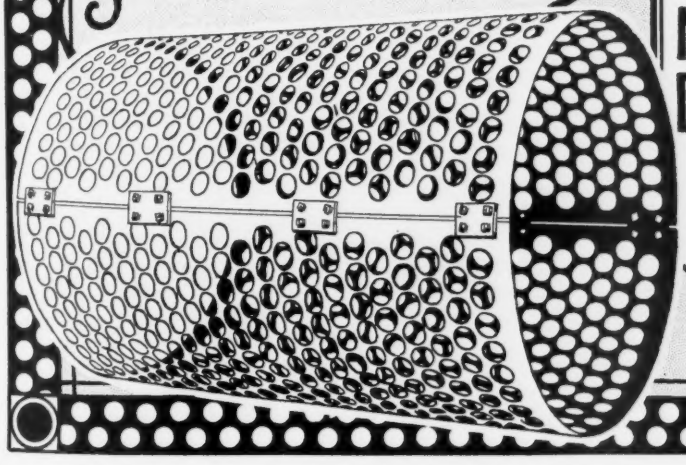
Read what one cement producer thinks:

> **"We have found the Sandvik Steel Conveyor Bands to be very reliable and strong and the wear has been so slight, the power consumption so low, that they are substantially cheaper and more advantageous than other heavy conveying apparatus and machinery."**

Every user is equally enthusiastic. Write for complete information. Ask for Catalog No. 18

SANDVIK STEEL, INC.
2001 Woolworth Bldg. New York City
Chicago Office—332 South Michigan Ave.

PERFORATED SCREEN SECTIONS



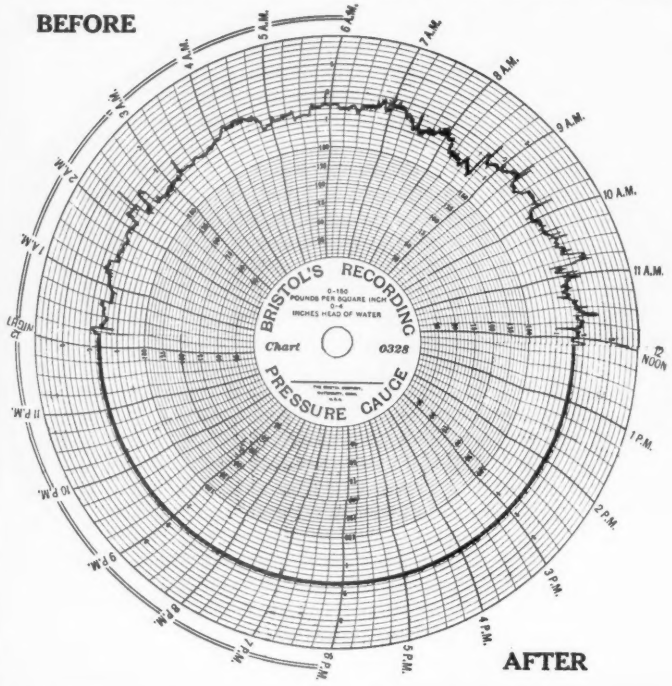
MADE TO SUIT YOUR REQUIREMENTS

NORTMANN DUFFKE CO.
1200-27th Ave.
MILWAUKEE
WIS.

3½ to 8% Saving in Coal Guaranteed

Typical Chart Record of Producer Gas Pressure With and Without the

BEFORE



AFTER

CHOWNING REGULATOR

Producer gas cannot be burned efficiently and economically in any furnace when the gas main pressure is irregular as shown by upper half of chart.

Since the supply of atmospheric **air** entering any furnace is under constant PRESSURE, in order to maintain a uniform temperature, the **gas** also must be under **CONSTANT PRESSURE.** Consequently, any type of furnace using producer gas regulated with a Chowning Regulator fulfills this requirement.

Any furnace burning producer gas so controlled not only uses 3½% to 8% less fuel but PRODUCES FASTER and with LESS furnace repair. The initial cost completely installed is recovered within from 3 to 6 months.

Send for Catalogues and Bulletins

Chowning Regulator Corporation
Corning, N. Y.

VULCAN KILNS

THE engraving above shows an installation of one of our 9 and 10x210 foot kilns at the Oswego Portland Cement Company, Oswego, Ore. Everywhere Vulcan owners are the greatest sales forces Vulcan posesses, for men know neither self interest nor gain in back of the impulsive praise owners give this kiln.

If you would know where complete kiln satisfaction exists, ask a Vulcan owner.

VULCAN IRON WORKS
Established 1849

1753 Main Street **Wilkes-Barre, Pa.**

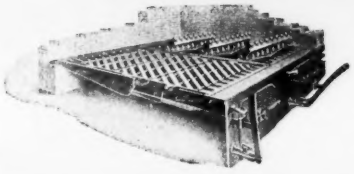
McGINTY GRATES—

These grates are especially designed to meet every requirement of Kiln and Hydrating practice.

Performance has demonstrated their economical value and wonderful efficiency. Performance has proved their ability to withdraw a higher degree of heat without warping than any other grate on the market.

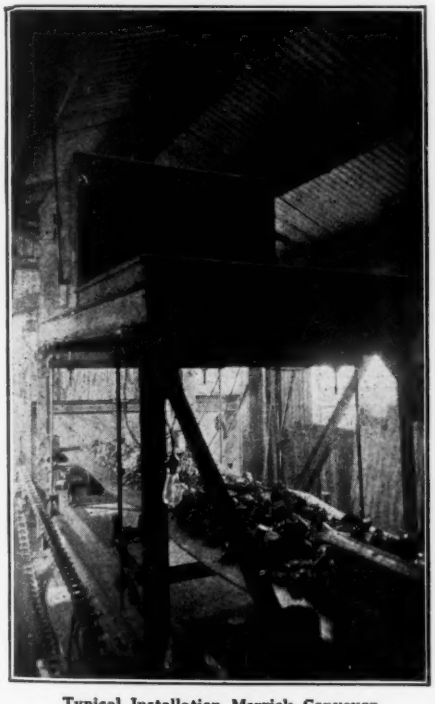
McGINTY Grates have a greater air area that permits the use of low grade coal and a deep fuel bed.

It is a sifting, shaking, and dumping grate, allowing fire to be cleaned with closed doors. A perfect satisfaction guarantee accompanies each grate.



The above engraving shows six Arnold Type Kilns at the Luckey Lime & Supply Company, Luckey, Ohio, all equipped with McGINTY Grates and all giving perfect satisfaction.

THE KRAMER BROS. FOUNDRY CO.
Dayton, Ohio



Typical Installation Merrick Conveyor Weightometer

The Merrick Conveyor Weightometer

Keeps Tab on Both Men and Conveyor

because it tells you with an accuracy GUARANTEED WITHIN NINETY-NINE PER CENT the weights of material handled by your belt, bucket or pan conveyor and gives you an accurate record in any unit desired. From these records the efficiency at which your conveyor is operated can be readily calculated as well as the exact cost per ton of handling your material or product conveyed.

Many prominent cement mills, quarries, and stone producing plants are using the WEIGHTOMETER for weighing stone, shale, rock, finished cement and coal.

The WEIGHTOMETER may be installed on any conveyor.

Send us details of your particular weighing problem and we will promptly furnish you with its solution

MERRICK SCALE MFG. COMPANY
180 Autumn St., Passaic, N. J.

Disabled Motive Power in Quarry Service Often Entails Heavy Losses Waiting for Repair Parts

IN the Rock Products industry, the use of motive power is essential. In many cases only a few locomotives are required, but in busy seasons, they must all be operated at fullest capacity.

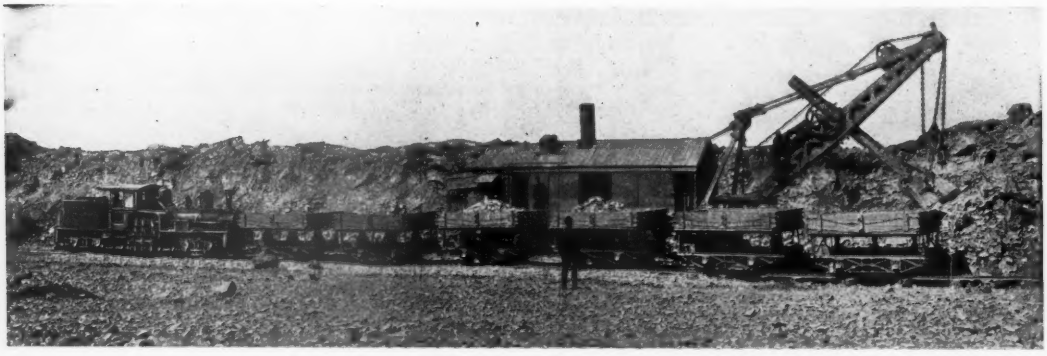
A breakdown under such conditions is serious. Often the field of operations is distant from the source of repair part supplies, and motive power disabled under such conditions means financial loss.

As builders of thousands of industrial locomotives of all types and sizes, and for all purposes, we are well equipped to manufacture and forward with the least delay, duplicate and repair parts, not alone for Baldwin locomotives, but also for those of other makes. We will also prepare for you, if requested, a list of parts most frequently needed which should be kept on hand to meet emergencies.

Baldwin Service is always at the command of Quarry Operators and Engineers

THE BALDWIN LOCOMOTIVE WORKS

Philadelphia



A Shay for *Every* Hauling Job

The Shay Industrial Catalog will tell you more about the Shay. Write for copy.

THERE'S a Shay for your hauling, a Shay that is big enough without being too big:

—a Shay that will cut your hauling costs.

—a Shay that works successfully on rough track.

—a Shay that will give you years and years of low-cost service.

Don't buy another locomotive until you ***know*** what a Shay Geared Locomotive will do on your job.

We have some interesting things to tell you about the Shay Geared Locomotive and what it is doing for others.

No obligation attaches to your request for this information.

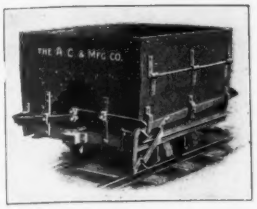
LIMA LOCOMOTIVE WORKS, Incorporated

17 East 42nd Street, New York Lima, Ohio

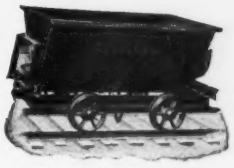
ATLAS CARS

ARE
DEPENDABLE HAULAGE EQUIPMENT
OFFERING
UNINTERRUPTED PERFORMANCE

"Built to Endure Under Toughest Service Conditions"

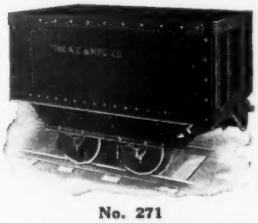


No. 161
Steel Gable Bottom Car

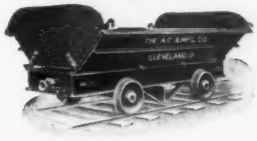


No. 217-S
Side Rocker Dump Car, small capacity. Plain wheels

A CAR FOR EVERY PURPOSE



No. 271
End Dump Car, with automatic trips on door



No. 258
Heavy Duty Quarry Car

No. 805
Dumping Stone Carrier

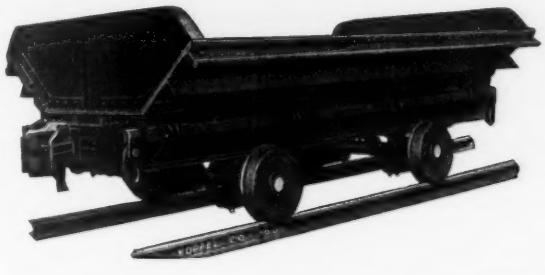
THE ATLAS CAR AND MANUFACTURING CO.

Manufacturers Engineers

Cleveland, Ohio, U. S. A.

KOPPEL ECONOMY—EFFICIENCY KOPPEL

You're sure of both when you equip your quarry with Koppel Cars and Track



Koppel Quarry Cars are built to stand the strain and hard usage of severe service.

Koppel Track, Switches and Frogs are designed right, and they're built right.

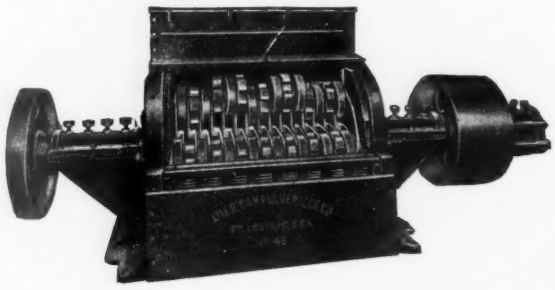
Let us solve your Hauling Problems

KOPPEL INDUSTRIAL CAR & EQUIPMENT COMPANY

Koppel, Pennsylvania

SALES OFFICES:

New York, 30 Church Street
Pittsburgh, Farmers Bank Bldg.
Chicago, Peoples Gas Bldg.
Detroit, Book Bldg.
Philadelphia, Commercial Trust Bldg.
Kansas City, Railway Exchange Bldg.
San Francisco, 51 Minna Street
Toronto, Canada, Ryrie Bldg.



American Ring Pulverizer

Here is another producer who knows there is nothing that equals the American Ring Pulverizer. His experience with this machine covering a period of five years taught him the American delivers the goods—that its built-in quality gives it the ability to stand up and deliver a service performance unequaled in dependability, efficiency and economy.

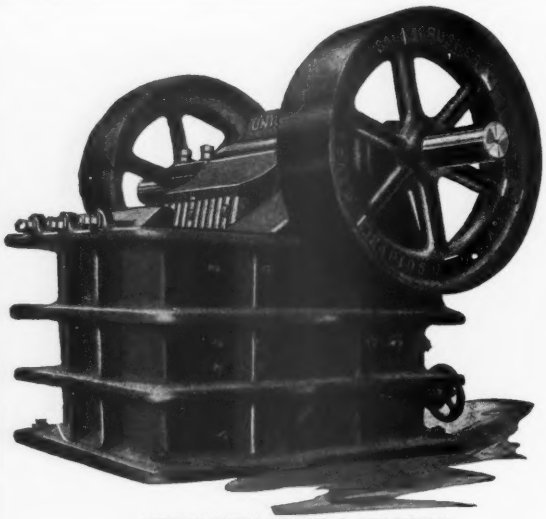
"We have used the American Pulverizer about five years, and it has done good work in hard limestone, reducing it to ¼-in. to dust in one operation.

"The American people are always prompt on repair parts ordered."

Truly yours,

Tarbox & McCall.
By H. McCall.

AMERICAN PULVERIZER CO., 18th & Austin, St. Louis, Mo.



HEAVY DUTY GENERAL CRUSHERS
12 x 20 in., 12 x 24 in., 12 x 36 in.
15 x 20 in., 15 x 24 in., 15 x 36 in.

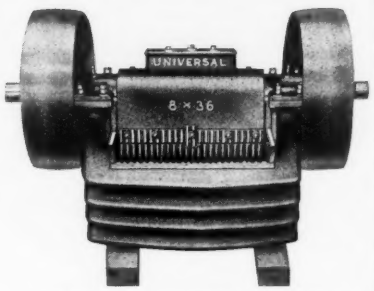
Recognized Leaders

For Capacity Production of Fine Crushed Stone and Gravel

Contractors, Road Builders, Pit and Quarry Operators and Highway Commissioners all over the country are asking the question—"How can we meet requirements for large quantities of fine crushed stone with speed and economy?" The simplest and best answer is

Use a Universal Crusher

**Capacities—
Two tons to 450
tons daily**



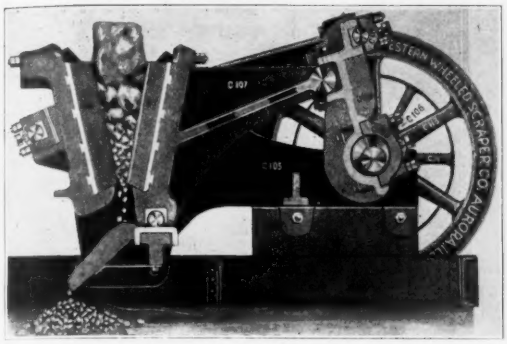
GRAVEL AND REJECTION CRUSHER
8 x 16 in., 8 x 18 in., 8 x 24 in., 8 x 36 in.

SUPERIOR FEATURES—Very simple in design and operation, unbreakable steel frames, best Manganese Steel jaws and liners, only one shaft, this of heavy high carbon steel and running in phosphor bronze bearings, efficient lubricating system and instant adjustment for any size material without stopping the machine.

STRONG, LIGHT, DURABLE, ECONOMICAL, DEPENDABLE

Mounted or unmounted, with or without elevators. Write us your requirements. Complete information promptly furnished.

Universal Crusher Company, 225 3rd St., Cedar Rapids, Iowa, U. S. A.



WESTERN - AURORA

The Jaw Crusher That is Different

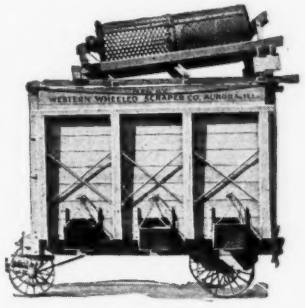
Different in design. Look at the sectional view. Not a time-wasting spring to break, or toggle to fall out.

Also—and what is even more important—a continuous double-stroke crushing motion which increases capacity, reduces vibration and economizes power.

The Western-Aurora Crusher is different in many ways that serve to speed up the work and fatten your pocketbook; and other units of the complete crushing and screening plant are on a par with it. Elevator, screen and bin—all are of the most substantial construction.

A Western-Aurora Crushing Plant is a mighty fine investment from every angle.

Other reasons are found in Catalog 44-T. We would like to send you a copy



THE AUSTIN-WESTERN ROAD MACHINERY CO.

Chicago, Illinois

Branches in 22 Cities

"Everything from a Drag Scraper to a Road Roller"

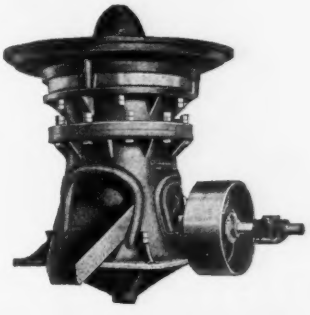
AUSTIN GYRATORY CRUSHERS

Stationary and Portable Types

Austin equipment in your crushing plant will solve your most difficult production problems. Austin Crushers have features found in no others, while Austin Elevators, Screens, Cars and other accessories are in a class with the crushers.

Maximum output with minimum delay is the combination responsible for the remarkable operating records made by Austin equipped plants.

Crusher Catalog 29-T tells the whole story. Drop us a card and we'll send you one by return mail.



AUSTIN MANUFACTURING CO.

New York Chicago San Francisco

Electrical Machinery

For Every Purpose in the Rock Products Field

Direct Current Generators
Direct Current Motors
Alternating Current Generators
Alternating Current Motors
Synchronous Motors
Crane and Hoist Motors
Elevator Motors
Motor Generator Sets
Arc Welding Equipments

BURKE ELECTRIC COMPANY
Main Office and Works
Erie, Pa.

SERVICE-SALES OFFICES:
Buffalo, New York, Cleveland, Philadelphia, Detroit, Pittsburgh

SALES AGENCIES
Cincinnati: Underwood Electric Co.
Kansas City: W. T. Osborn

METRO NITE
for Stucco

Metro-Nite White is a siliceous dolomite, extremely hard, sharp, cleanly graded and makes a bright, sparkling face for stucco buildings, concrete bricks or blocks.

It is generally accepted as the most beautiful and artistic facing known for this purpose, and we will gladly send samples to anyone who is interested in carload lots.

Metro-Nite can be delivered either in white or green.

THE METRO-NITE CO.
333 Hartford Ave., Milwaukee, Wis.

EVER-GREEN and EVER-RED
Slate Granules

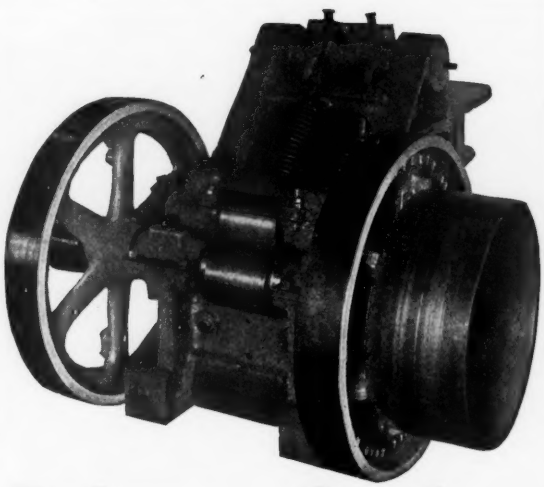
Ever-Green and Ever-Red Slate Granules, used in making slate surfaced roofing, slate flour as a filler in paints, mechanical rubber goods, linoleum, window shades, plastic roofing, roofing cement, and asphalt roads, can be used with telling effect

For the Facing of Concrete Blocks, Bricks or Stucco

The beauty, style and finish of a building covered with this material adds appreciably to its value.

It can be delivered carefully graded to size.

Write for samples and prices
VERMONT MILLING PRODUCTS CORP.
POULTNEY, VERMONT



Reliance Crushers

IN ALL SIZES FOR EITHER PORTABLE PLANTS FOR ROAD BUILDING OR STATIONARY QUARRY INSTALLATIONS.

BUILT FOR LONG, HARD SERVICE—WILL SAVE YOU MONEY IN THE LONG RUN

Let us quote you prices

Universal Road Machinery Co., Kingston, N. Y.
Branches in all principal cities in U. S. and Canada
MANUFACTURERS OF THE FAMOUS RELIANCE LINE OF ROAD BUILDING AND QUARRY EQUIPMENT

F. L. SMIDTH & CO.

50 Church Street New York

Engineers

CEMENT MANUFACTURING PLANTS

CEMENT MAKING MACHINERY

PULVERIZED COAL INSTALLATIONS

GRANULATING AND PULVERIZING MACHINES FOR ALL MATERIALS

FLINT PEBBLES—SILEX LINING

THE LENIX BELT DRIVE

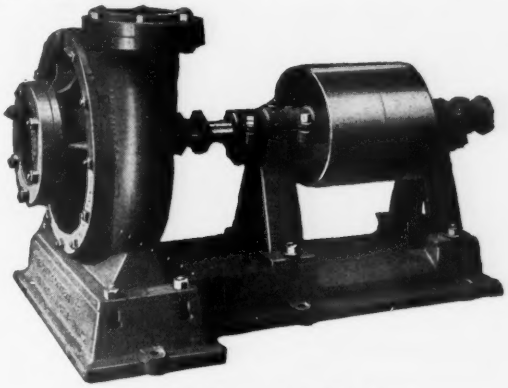
Webb City & Carterville Foundry & Machine Works

Webb City, Missouri

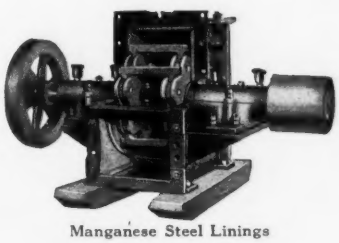
Engineers Founders Machinists

Complete Crushing Plants Designed

Manufacturers of rock crushing machinery: Jaw Crushers, Hercules-Giant and Heavy Duty Crushing Rolls, Screens, Centrifugal Pumps, Elevators, Stone Buckets, Sheet Metal Work, Stone Cars.



Write for descriptive literature



Manganese Steel Linings

USERS OF

"K-B" PULVERIZERS

requiring additional tonnage are ordering "K-B" equipment.

May we tell you why?

K-B PULVERIZER

K-B Pulverizer Co., Inc.
92 Lafayette Street
New York

Schaffer Hydrator

There is far more than average satisfaction in the superior kind of performance and reliability with which the

SCHAFFER HYDRATOR

is so universally credited. Every producer who is acquainted with this remarkable piece of machinery is enthusiastic when talking of its dependability, its flexibility of control and the quality of hydrate it produces.
The Schaffer is automatic in operation, solving the labor problem, and will successfully handle either high calcium or dolomite lime.

Let us explain its operation in detail

SCHAFFER ENGINEERING & EQUIPMENT CO.
2828 Smallman Street
Pittsburgh, Pa.

MANGANESE STEEL

THE FIRST ERA STILL LEADS IN QUALITY

THE HADFIELD-PENFIELD STEEL COMPANY
BUCYRUS, OHIO

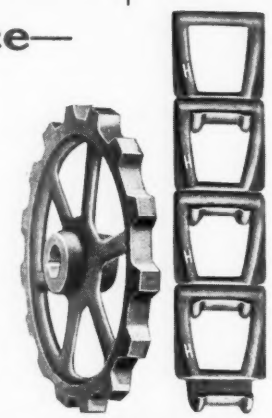
Longer Service—

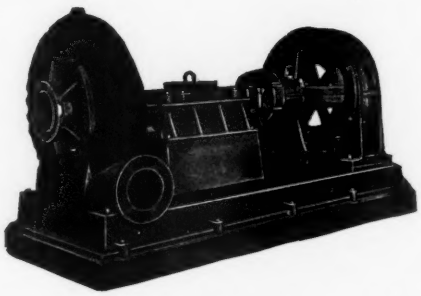
You will be free from the constant worry of shut-downs if you will carry a line of ERA repair parts.

Gyratory Crusher Parts—Heads, Concaves and Renewable Mantles, Gears and Pinions and Wearing Plates.

Jaw Plates, Cheek Plates, Toggles and Toggle Bearings.

Standard detachable chains of all sizes and Sprocket Wheels.





Heavy Service Dredging Pump

Where conditions are too severe for our standard sand pump, the above type is recommended.

It is built in sizes from 4 in. up, arranged for belt, motor, or engine drive.

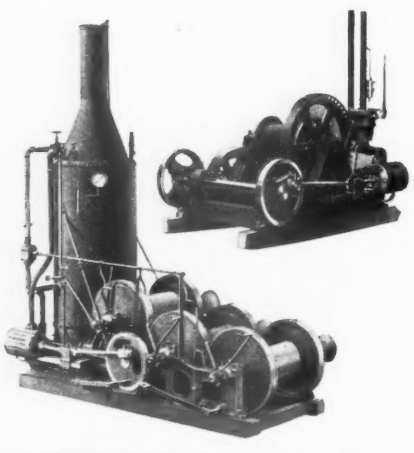
MORRIS MACHINE WORKS
50 Genesee St. Baldwinsville, N. Y.

39 Cortlandt St., New York City
Forrest Bldg., Philadelphia, Pa.
217 N. Jefferson St., Chicago, Ill.
Penobscot Bldg., Detroit, Mich.

Bulletin No. 19-B fully describes our complete line of sand and dredging pumps. Have you your copy?

MORRIS

Since the Civil War Builders of Centrifugal Pumps, Hydraulic Dredges, and Steam Engines



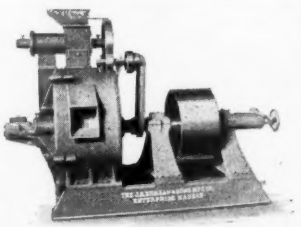
The "AMERICAN" Heavy Duty Clamshell Derrick Engine is a Profit Builder

When you buy a clamshell derrick hoist the big thing to be sure of is ample capacity. There will be no question about this if you buy an "AMERICAN" Heavy Duty Clamshell Derrick Engine—9x10 size for a 1½-yard bucket; 10x12 size for a 2-yard bucket—and an "AMERICAN" 5x7 or 7x8 Independent Slewing Engine.

AMERICAN
HOIST & DERRICK CO.
Saint Paul, Minn.

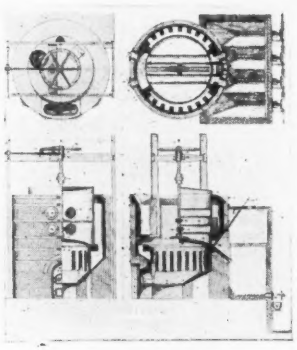
New York - Chicago - Pittsburgh - Seattle - New Orleans - Detroit

These fine grinding mills are made in two sizes. A 36-in. Vertical Mill arranged for belt or direct connected motor drive, and a 42-in. Horizontal Mill for belt drive. They are fitted with American, French Burr or Rock Emery Stone.



Vertical Grinding Mill

EHRSAM



Calcining Kettles

Ehrsam Calcining Kettles are made in standard sizes: 4x4 ft., 5x5 ft., 6x6 ft., 8x8 ft., 10 x 8 ft., 12x8 ft., and 14x8 ft. They are complete with the exception of Brick Setting.

We also manufacture Hair and Fibre Pickers, Elevators and Conveying Machinery, Hammer and Revolving Screens, Power Transmission Machinery.

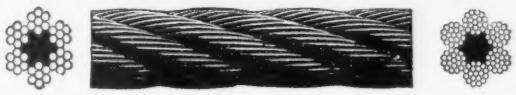
Inquiries Given Immediate Attention

The J. B. Ehrsam & Sons Mfg. Company
Enterprise, Kansas

WIRE ROPE

There is unusual strength, toughness and durability built into both the Monarch Whyte Strand Wire Rope and Macwhyte Galvanized Cast Steel Guy Rope. Because of their durability these brands are safe and economical.

The "Monarch Whyte Strand" Wire Hoisting Rope is composed of six strands of nineteen wires each and has one manila center—the wires have a breaking strain of from 220,000 to 280,000 lbs. per square inch, and at the same time are extremely tough.



(6x7) (6x19)

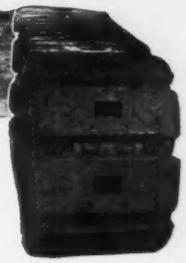
The Macwhyte Galvanized Cast Steel Guy Ropes are composed of six strands—seven wires or nineteen wires in each strand. These ropes are built to stand all atmospheric conditions and are extremely durable.

MACWHYTE COMPANY

Kenosha, Wisconsin

POWER STEERING, from the cab, saves you a man's wages. Not necessary to have a man on the ground to throw clutches for steering.

CLIMBS GRADES as steep as 30% (engineer's measurement).



Buy a Caterpillar type shovel that is

UP-TO-DATE

If you have used any other caterpillar type steam shovel, you will see at once that the ERIE is far superior. It is automatically *lubricated,* from internal oil reservoirs. This greatly reduces friction—it gives you several times the climbing power. More than twice the speed of other caterpillar type shovels. It also assures you of steadier service and a much lower upkeep cost.

These features of the new 1922 ERIE, and many others, are interestingly described in our Bulletin P-60. *Write for a copy.*

The treads of the caterpiller type ERIE are all-steel, practically indestructible. No broken wooden fillers to replace, nor bent channels to repair. Every link pin is bushed, so that there is no wear on the link itself. Bushings when worn are easily replaced at slight expense.

ERIE STEAM SHOVEL CO., Erie, Pa., U. S. A.
Builders of Erie Steam Shovels and Locomotive Cranes

ERIE Revolving Shovels Steam

THE IRONTON

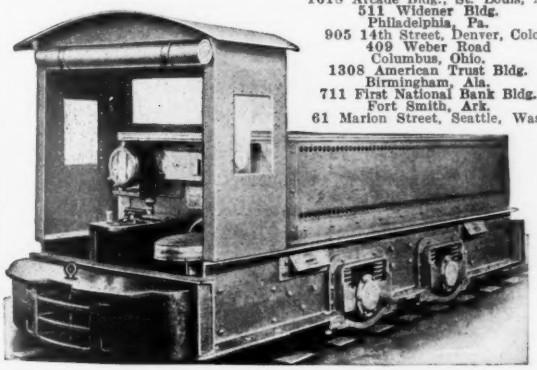
STORAGE BATTERY LOCOMOTIVE

IN West Virginia, 80 per cent of all storage battery locomotives in use today are Irontons! This must be conclusive proof that the Ironton Storage Battery Locomotive gives more efficient, more economical hauling power. This must be proof that your money is invested most advantageously in an Ironton Locomotive. Quality —service—satisfaction—why not for you, too?

The Ironton Engine Co. **Ironton, Ohio**

561-B Union Arcade Bldg.
Pittsburgh, Pa.

Branch Offices:
816 Robson Prichard Bldg.
Huntington, W. Va.
1618 Arcade Bldg., St. Louis, Mo.
511 Widener Bldg.
Philadelphia, Pa.
905 14th Street, Denver, Colo.
409 Weber Road
Columbus, Ohio.
1308 American Trust Bldg.
Birmingham, Ala.
711 First National Bank Bldg.
Fort Smith, Ark.
61 Marion Street, Seattle, Wash.



NEWARK

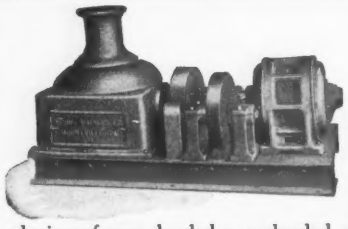
Newark "Lock Crimp" Heavy Steel Wire Screens are made in special sizes from coarsest to finest mesh.

This is a durable wire screen, assuring a clean, even graded product at low cost. In fact it is this ability to do better screening at lower cost that has made this product the standard of screening value.

Newark Wire Cloth for fine screening is unequaled in value
Use Standard Testing Sieves

NEWARK WIRE CLOTH CO.

Newark, New Jersey



The "HANDY MAN" Car Puller

This car puller equipment will give you absolute control in the spotting or replacing of cars, loaded or unloaded, and without regard for weather conditions. It will pull cars from either direction, is exceptionally compact and rugged in construction, can be installed in a limited space, and motor is protected by metal cover.

Furnished in type and size to meet your special needs—Motor or Belt drive. The "Handy Man" is a real money saver.

MINING MACHINE CO., MOUNTVILLE, PA.

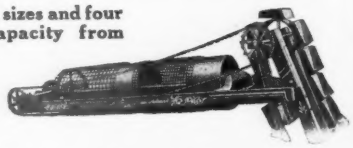
Engineering Service—

This organization designs and builds Lime and Hydrated Lime, Cement and Plaster plants after making a scientific study of each proposition.

Richard K. Meade & Company
11 E. Fayette St. Baltimore, Md.

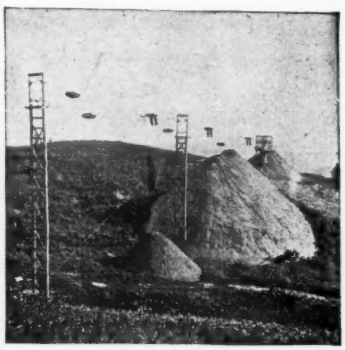
New Holland Revolving Screens

made in three different sizes and four different lengths — capacity from one to two hundred tons per hour.



Write for catalog and prices on revolving screens, jolt screens, elevators, conveyors, and primary or secondary rock crushers.

NEW HOLLAND MACHINE COMPANY
New Holland, Pa., U. S. A.



SPELL

Low Hauling Costs
Continuous Operation
Great Saving with Small Investment

CERTAINLY!

Automatic Aerial Tramway

Let Us Demonstrate

Interstate Equipment Corporation
25 Church Street
New York City

Chicago Office: Railway Exchange Bldg. New York: 30 Church St.

Robert W. Hunt Jno. J. Cone D. W. McNaugher

ROBERT W. HUNT & CO.

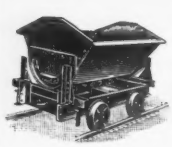
Inspection—Tests—Consultation

Inspection New and Second Hand Machinery, Pumps, Crushers, Steam Shovels, Cars, Locomotives, Rails and Quarry and Contractors' Equipment

INSPECTION AND TESTS OF SAND, GRAVEL, CEMENT, STRUCTURAL STEEL, CASTINGS AND CONSTRUCTION MATERIALS

Cement, Chemical and Physical Testing Laboratories

CHICAGO
2200 Insurance Exchange
New York St. Louis Kansas City Cincinnati Pittsburgh San Francisco



Industrial Cars and Dumping Buckets of All Kinds

Specialize in

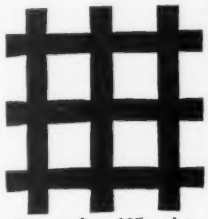
Hoppers, Bins, Bin Gates, Chutes

Penn Foundry & Manufacturing Company
Hillcrest, Reading, Pa.

BACON-FARREL ORE & ROCK CRUSHING-WORLD KNOWN ROLLS-CRUSHERS

EARLE C. BACON, INC. ENGINEERS
26 CORTLANDT ST., NEW YORK

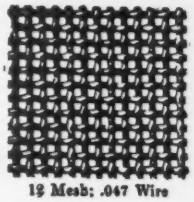
"CLEVELAND" DOUBLE CRIMPED WIRE CLOTH



2½ mesh; .105 wire

A uniform fineness is assured by the use of "Cleveland" Double Crimped Wire Cloth, making it unequalled for the screening of Sand, Gravel, Crushed Stone and Cement. "Service" is the definite policy of this organization, and through every phase of manufacture this end is constantly before us.

A large stock always on hand. However, any special mesh will be manufactured to suit requirements. PRICES RIGHT

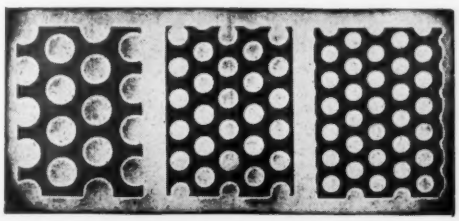


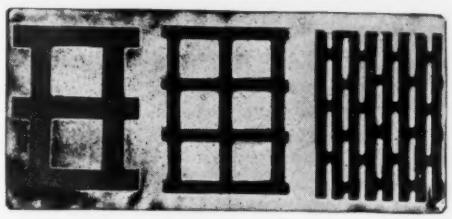
1¾ Mesh; .047 Wire

THE CLEVELAND WIRE CLOTH AND MANUFACTURING COMPANY

3573 East 78th Street **Cleveland, Ohio**

Perforated Steel Screens





For Screening Stone, Gravel, Sand and Cement

All sizes and shapes of holes in metal of proper thicknesses to give the best screening results.

Sheets furnished flat or rolled to shape for revolving screens.

THE HARRINGTON & KING PERFORATING CO.

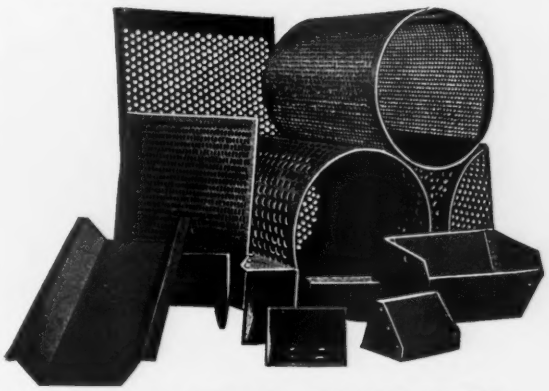
621 N. Union Ave., Chicago, Ill.

NEW YORK OFFICE: 114 Liberty St.

Perforated Metal Screens

FOR

Stone, Gravel, Sand, Etc.



ELEVATOR BUCKETS

PLAIN AND PERFORATED

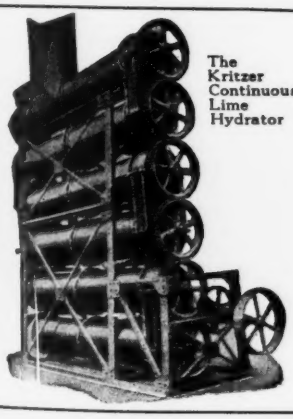
General Sheet and Light Structural Work

"Light and Heavy Steel Plate Construction"

HENDRICK MFG. CO.

CARBONDALE, PA.

New York Office, 30 Church Street
Pittsburgh Office, 544 Union Arcade Bldg.
Hazleton, Pennsylvania, Office, 705 Markle Bank Bldg.



The Kritzer Continuous Lime Hydrator

HYDRATE

Years ago we helped our customers create a demand for their hydrate. Today the demand exceeds the supply. That's why every lime manufacturer should have an efficient, economical hydrating plant.

THE KRITZER Continuous Lime Hydrator is efficient in production and economical in operation and maintenance. Let us investigate exhaustively the local conditions peculiar to your proposition, and then apply our experience of many years and design a plant to meet those conditions.

A KRITZER plant, scientifically adapted to your conditions, will give you the best product at lowest cost

THE KRITZER COMPANY

503 South Jefferson Street CHICAGO, ILL.

Used Equipment

Rates for advertising in the Used Equipment Department: $2.50 per column inch per insertion. Minimum charge, $2.50. Type ads only. No cuts or illustrations permitted unless at the regular display advertising rates. Please send check with order. These ads must be paid for in advance of insertion

IMMEDIATE SHIPMENT

2—Austin No. 3 Gyratory Crushers.
2—Bonnot 5′x22′ Compeb (tube) Mills.
1—Vulcan 8′x100′ Rotary Kiln.
1—Vulcan 7′x120′ Rotary Kiln.
1—Renneberg 5½′x45′ Ore Dryer.
4—American Process 4′x30′ Rotary Dryers.
2—Hardinge 8′ Conical Mills.
1—Link Belt 20-Ton Hourly Coal Crusher.
Raymond, Kent and Fuller Mills.
Swing Hammer Mills, all makes.
Buchanan and Sturtevant Crushing Rolls.
Jaw, Gyratory and Disc Crushers.
Complete Experimental Cement Plant.

High Grade Used Machinery for the Entire Rock Products and Non-Metallic Mineral Industry Our Specialty

American Machinery Equipment Co., P. O. Box No. 292, Charlotte, N. C.

FOR SALE

2—8x110′ Rotary Kilns.
5—5x6x7x110′ Rotary Kilns.
5—5x21′ Tube Mills (1 has Silax lining, 3 steel lining, 1 without lining).
1—4′ 6″x29′ Coal Dryer.
2—No. 6 Gates Crushers.
3—5½x22′ Tube Mills.
2—6x50′ Rotary Dryers.
3—Kominuters.
6—Krupp Ball Mills.
3—33″ Fuller Mills.
2—6x60′ Rotary Dryers.

ENGINEERING SALES COMPANY, Nashville, Tenn.
OLLIE LAWRENCE, Stockertown, Pa.

CRUSHERS

1—60x84 P. & M. Jaw
1—24x48 Buchanan Jaw
1—10x16 Farrell Jaw
2—No. 8 Style K Gates Gyratory
2—No. 6 Style K Gates Gyratory
5—No. 5 Style K Gates Gyratory
6—40x15 in. Anaconda Sand Rolls
3—54x20 Anaconda Sand Rolls

LOCOMOTIVES

Standard Gauge—Saddle Tank

1—13x20, 6 wh. Baldwin
4—13x18, 4 wh. American
11—14x22, 4 wh. American

STEAM SHOVELS

1—100C Bucyrus 3½ yd. Dipper
1— 95C Bucyrus 3½ yd. Dipper
1— 73 Osgood 3 yd. Dipper
2— 70C Bucyrus 2½ yd. Dipper

Write for Screens, Dump Cars, Steel Derricks, Hoists, Compressors

T. H. Letson Company
46 Church Street New York

FOR SALE

BARGAIN

Emerson, Brantingham Hoists
UNUSED

DOUBLE CYLINDER, SINGLE DRUM, IN FIRST CONDITION

$150.00 Each F.O.B. Chicago

Capacity 10,000 Pounds
IMMEDIATE SHIPMENT

Detailed Specifications Furnished on Application

"QUANTITY IS LIMITED"

Hyman-Michaels Co.
531 Peoples Gas Bldg., Chicago, Ill.

WANTED

Air separator 18′, prefer Gayco. Advise present condition, location, price, etc. Also one belt or chain elevator, 75 to 80 ft. centers, with about not less than 7 x 14 buckets complete. Address

Box 1631, Care of Rock Products
542 So. Dearborn St.
Chicago, Ill.

Special Bargains

Send Us Your Boiler Inquiries

66x86-in. Traylor Jaw Crusher
No. 18K Gates' Crusher
25-50-80-110 H. P. Elec. Hoists
Nos. 4-5-6-7½-9 and 10 Crushers
6 and 12-ton Gasoline Locomotives
2-Disc Crushers, 36 in. Symons
100-ton, 2½-yd. Electric Shovel
50-5000 ft. Steam Belt and Electric Compressors
13-30 in.; 10x18 in.; 9x14 in. Jaw Crushers
24x54 McLanahan Roll Crusher
50 H.P. D. D. Hoist, 440-v., 3 ph. Motor Dragline Set
New G. E. Gas Engine Sets, 5-25KW.
New 1000 g. p. m. Pump, 440-v., 3 ph. Motor
1000 g. p. m. Underwriters Steam Pump

Send Us Your Inquiries for Your Wants

Ross Power Equipment Co.
Indianapolis, Ind.

WANTED

Second-hand Krupp Tube Mill, in good condition, size 6x16.

Security Cement & Lime Company
Hagerstown, Maryland

FOR SALE

Monighan Dragline, 75 ft. boom, 2 yd. bucket
Lidgerwood Dragline, 60 ft. boom, 2 yd. bucket
Monighan Dragline, 40 ft. boom, 1 yd. bucket

J. A. Donahue
20 W. Jackson Blvd. Chicago, Ill.

For Sale—STEAM SHOVEL

⅝ YD. THEW "O" TRACTION

Thoroughly rebuilt; attractive terms for quick sale.

Walter A. Zelnicker Supply Co., St. Louis
Rails, Locomotives, Cars, Tanks, Pipe

Used Equipment

Rates for advertising in the Used Equipment Department: $2.50 per column inch per insertion. Minimum charge, $2.50. Type ads only. No cuts or illustrations permitted unless at the regular display advertising rates. Please send check with order. These ads must be paid for in advance of insertion

FOR SALE

1—John O'Laughlin No. 1 Gravel or Stone Screen, complete and in good condition. 4 Jackets.

1—Dean Bros. double-acting duplex Steam Pump, 7x6; used only few months.

1—Fairbanks-Morse 5x4 centrifugal Water Pump; good condition.

Priced to sell f. o. b. Riverton, Ind. I. C. R. R.

Merom Gravel Company

208 Indiana Trust Bldg., Indianapolis, Ind.

FOR SALE

One W. S. Tyler Co. Hummer Electric Screen with four sets wire in frames and suitable for sand screening. This machine is practically new, used but one month. For particulars address

Box 1635, care of Rock Products
542 South Dearborn Street Chicago, Illinois

Machinery For Sale

DRYERS—Direct-heat rotary dryers, 3x25′, 3½x25′, 4x30′, 5½x50′, 6x60′ and 7x60′; double shell dryers, 4x20′, 5x30′ and 6x35′; steam-heated air rotary dryers, 4x30′ and 6x30′.

KILNS—Rotary kilns, 4x40′, 5x50′ and 6x70′, 6x100′, 7x80′ and 8x110′.

MILLS—6x8′, 6x5′, 5x4′, 3x3½′ pebble and ball mills; 3′ March mill; 42″, 33″ and 24″ Fuller-Lehigh mills; 4½x20′, 5x11′, 5x20′, 5½x22′ and 6x20′ tube mills; 7½x13″, 9x15″, 16x10″ and 12x26″ jaw crushers; one "Infant" No. 00, No. 0, No. 2, No. 3, and No. 9 Williams' swing hammer mills; one Kent type "G" mill; 24″, 36″ and 40″ cage mills; 3′ and 4½′, 6′ and 8′ Hardinge mills; 18x12″, 20x12″ and 30x10″ roll crushers; No. 0, No. 1 and No. 3 Sturtevant rotary crushers; one No. 2 Sturtevant ring roll crusher; 5 roll and 2 roll No. 1 and No. 000, No. 00 and No. 0 Raymond mills; one No. 3 and No. 4 and No. 7½ Pelsmith breaker; one 36″ Sturtevant emery mill; one 3 roll Griffin mill; 60″ chaser mill.

SPECIALS—Five automatic package weighing machines; jigs; 6x8′, 6x5′ and 4x3′ Newaygo vibrating screens; Richardson automatic scales; 8′ and 10′ Emerick air separators.

Air compressors.

W. P. Heineken, Engineer

95 Liberty Street, New York. Tel. Cortland 1841

2—50-ton standard-gauge Baldwin 6-wheel switchers, built 1913.

1—42-ton standard-gauge Shay geared locomotive.

1—12x18 in. standard-gauge 4-wheel saddle tank.

10—5-ton 36 in. gauge storage battery locomotives.

1—14-B Bucyrus steam shovel, mounted on traction wheels.

30—Miles 56-lb. relay steel rails; Hawkinsville, Ga.

30—Miles 50-lb. and 56-lb. relay steel rails; Percy and Webb, Miss.

Birmingham Rail & Locomotive Co.

Birmingham, Alabama

USED ONLY THREE MONTHS

Steam Shovels

Osgood Steam Shovels, No. 29, 30 ft. booms, 20 ft. sticks, Caterpillar traction, Steam boom hoists and 1-yd. dippers. Also several with 20 ft. booms, 17 ft. sticks, steam boom hoists and caterpillar traction. (The above shovels were shipped from the factory in September, 1922, and have been used less than three months and are in excellent condition. These shovels are EXCEPTIONAL BARGAINS.)

15—Other Steam Shovels of different makes, types, and sizes.

Stone Crushers

9—Stone Crushers of various sizes and makes.

Stocking Bridges

3—Large bridges for stocking or reclaiming material such as sand, gravel, clinker, coal, etc.

Cranes

1—No. 3 Byers Crane, ¾-yd. bucket, caterpillar traction.

EXCEPTIONAL BARGAINS

Cableways

2—Cableway dragline outfits of 1-yd. and 1½-yd. capacity.

Boilers

25—Boilers 20 to 1000 H.P.

Engines

30—Steam, Gasoline and Gas Engines of various sizes and makes.

Hoists

1—Clyde, three-drum, Hoisting Engine, 2-cylinders, 8¼x10 in. With this hoist is a 5x6 swinger engine.

Also several other hoists of various sizes and makes.

Locomotives

5—Steam and Gasoline Locomotives.

Write for description of Cars, Conveyors, Derricks, Elevators, Pumps or any kind of Pit, Quarry or Contractors equipment and I will send you notice of machines available in your vicinity.

1515 First National Bank Bldg. A. T. McLEOD CHICAGO

FOR SALE

No. 3 Austin Gyratory Crusher complete.
2 No. 2 Climax 9″x16″ Jaw Crushers complete.
1800 ft. No. 4 d.b. and w.p. electric wire.
50′ Cont. bucket and chain elevator, buckets 8″x16″.
75 H.P. 13″x16″ side crank Erie City Steam Engine.
9″x14″ Vulcan Locomotive No. 981 complete.
2 G.E. 150 H.P. Induction Motors, voltage 220-440, shop numbers 625140 and 1164925—complete with starters.
Williams No. 9 Universal type swing hammer pulverizer complete.
Kent three-roller pulverizer.
10″x8″x20″ Worthington St'm Pump No. 16876.
Sanderson Cyclone No. 14 well drill, either electric or gasoline driven, complete.
Austin Standard Revolving Screen 40″ diam. by 20′ long, complete.
Williams No. 2 Pulverizer.
No. 1 Sturtevant Open Door Crusher.

E. W. COOPER, Engineer

174 3rd Ave. North Nashville, Tenn.

FOR SALE

2—48 ton six-wheel switchers, good condition
1—Monighan Dragline, 70 ft. boom, 2 yd. bucket
2—8 ton Vulcan 24 in. gauge Dinkies
1—10 ton Davenport 24 in. gauge Dinkey
2—3½ ton Burton 24 in. gauge gasoline Dinkies
Lot miscellaneous Concrete Mixers, Pumps and Pile Driving Equipment

THE FRED R. JONES CO.

Contractors

111 West Washington St., Chicago, Ill.

IMMEDIATE DELIVERY

1—7½x13-in. Champion Jaw Crusher; excellent condition ---------- $300.00
7—1¼ yd. end dump wood quarry cars, 30-in. gauge ---------- 85.00
Trucks alone worth this money
1—12x16-in. Chandler Taylor Steam Engine, side crank left hand, self contained, slide valve; 17x72-in. band flywheel, shop No. 6070; excellent condition ---------- 350.00

CERULEAN STONE COMPANY
Cerulean, Trigg County, Ky.

Mine Cars, Rails and Ties

We have mine cars in stock for all purposes. Also rails 12 lb. to 100 lb. section. Spikes, bolts, frogs and switches. All trade is solicited and prices cheerfully quoted.

M. K. FRANK

Frick Building Pittsburgh, Pa.

CRUSHER PLANT

24x36 Buchanan Jaw Crusher, and 48 in. Symons Disc Crusher, with elevators, screens, line shafting. In Oklahoma.

Dump Cars

9—1 yd. 30 in. Ga. V-shape
6—1½ yd. 24 in. Ga. Western
12—4 yd. 36 in. Ga. Western

Rails

230 tons 25 lb. Relayers
180 tons 30 lb. Relayers
165 tons 35 lb. Relayers
Also 60, 70, 75 and 80 lb. Rails

Mid-Continent Equipment & Machinery Company

Security Bldg. St. Louis, Mo.

Classified Advertising

Rates for advertising in the Used Equipment Department: $2.50 per column inch per insertion. Minimum charge, $2.50. Type ads only. No cuts or illustrations permitted unless at the regular display advertising rates. Please send check with order. These ads must be paid for in advance of insertion

For Sale or Lease

A small, modern equipped crushing and pulverizing plant and quarry, consisting of about 50 acres underlaid with a high quality Clinton strata blue limestone, 30x500 ft., open face, dry quarry; 94.20 carbonate, extra quality road stone; also makes extra strong burned lime. Big local demand. Plant in operation. Fine location for a larger plant, as it is located in a territory of splendid markets and has a great future industrially. Plant near Lynchburg, Ohio. Want to retire on account of age and health. Call on or address

FRANK SHARP
Lynchburg, Ohio

Will Sell My Two Phosphate Plants

One plant in operation. Cost of plants $125,000. Equipped for mining hard and soft phosphate; 50 to 75 tons per day each; 125 miles from Jacksonville, located in the high grade hard rock phosphate belt. Analysis 76 to 82 B. P. L. I. and A. 2 to 3. Estimated over 300,000 tons of hard rock. One-half million tons of soft rock. Analysis, phosphoric acid, 24 to 32. Five hundred acres of land together with dwelling houses, phosphate bins and all other necessary buildings for laborers. One-quarter mile R. R. side track to each plant from A. C. L. R. R., main line. Will take fifty cents on the dollar for its actual value. $50,000 cash will secure the property, balance of payments, reasonable terms, or royalty basis. For further information, if interested, write me, the owner,

J. Frank Meredith
Dunnellon, Fla.

FOR SALE

Exceptional river gravel proposition in western Missouri—meets state highway specifications. Large territory tributary for road work, and commercial business in concrete and roofing gravel. Served by 'Frisco and "Clinton" railroads. Opportunity for capable man to make big money. Act promptly. Address

Box 1633, care of Rock Products
542 South Dearborn Street Chicago, Illinois

Gypsum For Sale

I have two million (2,000,000) tons pure gypsum and gypsite for sale close to the Frisco R. R. in Oklahoma. Write for particulars.

H. E. WILSON
Box 307, Fairfax, Okla.

FOR SALE—CEMENT LAND

A body of land situated on the Tombigbee River, and Southern Railway, four miles from Demopolis, Ala., containing great quantity fine cement rock. An ideal location for Cement Plant. Good transportation facilities and cheap rates.

C. J. WISE, York, Alabama

WANTED

Master Mechanic for Crushed Stone Plant, experienced with jaw and gyratory crushers, derricks and steam engines, to take charge of machinery. Output 500 tons per day. House supplied free, school about a mile away. Advise experience and wages expected in first letter. Only high class experienced men need apply. Permanent position for capable man.

Neverson Granite Quarry
Sims, N. C.

WANTED

Man to take charge of eight large lime kilns. Must be experienced and capable of keeping records and handling men. Good wages. State experience and full details in first letter.

Hunkins Willis Lime & Cement Co.
904 Century Building St. Louis, Mo.

WANTED

Experienced operator for Sauerman Cableway Thomas Electric Hoist. Must be capable of keeping machinery in tip-top shape. Have steady position for a good steady operator. State age, experience, and salary expected in first letter, and must be ready to come by March first. References.

J. E. IRVINE, Green River, Wyo.

H. E. WIEDEMANN

(Est. 1905)
Consulting and Analytical Chemist
Specialist in Analysis of Rock Products
Chemical Bldg. St. Louis

George Borrowman, Ph.D.

CHEMIST

Analyses, consultations, researches in connection with rock products, cements, clays, lime, plasters, zeolites, sands, etc.
9 So. Clinton St. Chicago, Ill.

FOR SALE

10 ton 36-in. Gauge American Locomotive
3 36-in. Gauge 4 yd. 2-way Dump Cars
15 H.P. Fairbanks Gasoline Engine
1 50 H.P. Wetherill Corliss Engine

ATLAS CO. Mertztown, Pa.

Position Wanted

Quarry Engineer, Associate Member, American Society of Civil Engineers. Age 36; single; three years' experience railroad and building construction. Past 12 years quarrying and open pit mining. Qualified by experience and business training for executive in charge of operations of large cement or steel companies, quarries or open pit mining properties. Familiar with well drilling, steam shovel operations, and use of high explosives. A believer in organization and cost accounting. Qualified to make investigations, build up an organization and get results. Familiar with lime kilns and hydrating plants. At present employed but desirous of change. Location immaterial. References furnished, but personal interview preferred. Address

Box 1628, care of Rock Products
542 South Dearborn Street, Chicago, Ill.

WANTED

A connection, where I can utilize my years of experience as a quarry operator and develop a plant where I can have a real interest. Thoroughly conversant with quarry development, plant erection, economical production, sales, etc. References from past connections. Address

Box 1634, care of Rock Products
542 South Dearborn Street Chicago, Illinois

SUPERINTENDENT

desires engagement, operation of ballast or crushed stone plant. Twenty years' experience handling labor, heavy machinery, heavy blasting and large production. Familiar with all details. Excellent references. Address

Box 1613, Care of Rock Products
542 South Dearborn Street, Chicago, Ill.

WANTED

Position as superintendent of sand plant mill and quarry. Man with 16 years' experience in mill and in quarry. Spring is coming on. Now is the time to prepare for a good output at low cost. Address

Box 1632, care of Rock Products
542 South Dearborn Street Chicago, Illinois

General Crushing and Quarry Man

will be open for position in 30 days. Where complete charge of operation is required system must not prevent changes in methods. If you require man to go strictly to your dictation don't reply; any one will do. I co-operate. Address

Box 1630, care of Rock Products
542 South Dearborn Street Chicago, Illinois

Crusher Man

Wishes to communicate with anyone east of Rockies having crushing plant with good quarry that would lease operation, owners to handle sales preferred; 500 to 1000-ton operation. Address

Box 1629, care of Rock Products
542 South Dearborn Street, Chicago, Ill.

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IDEAS—

You could use an idea now and then, couldn't you?
You'll find plenty of new ones, short cuts and time savers in ROCK PRODUCTS.

Our traveling editors are running around, dropping in here and there finding out just how things are done, and then they tell you how the other fellow makes things hum.

Practical stuff—tested ideas—something *you* can use
Better fill out the blank and mail it to us today

ROCK PRODUCTS Date.....1922
542 So. Dearborn St., Chicago, Ill.

Please enter my subscription to ROCK PRODUCTS for.....year.... (one year $2.00, two years $3.00—please state which. You save a dollar by subscribing for two years), for which we enclose $..... Canadian and Foreign Subscriptions $3.00 a year.

Name.....

Street.....

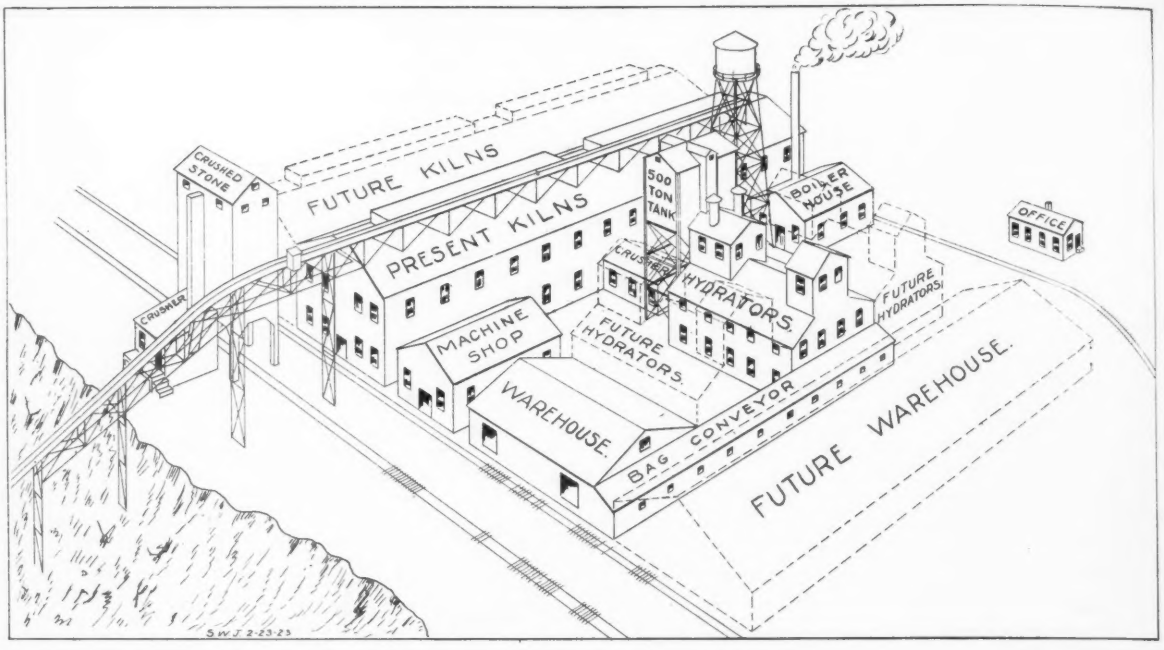
City..... State.....

We produce:.....

.....

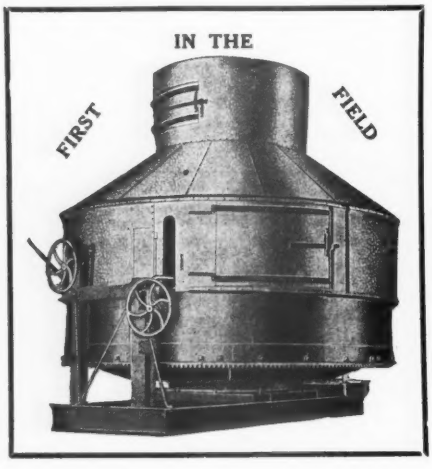
.....

We retail.....



ENGINEERING the Complete Lime Plant

A man may learn to drive a nail precisely but he is a dangerous man unless he knows the effect of the driving upon the materials into which the nail enters. Progress requires exactness of information. Our organization, with its wide, practical skill and technical knowledge, supplies this requirement. A complete engineering service is placed at your disposal. We design and build the complete lime plant or any part of it. Avail yourself of the services of experts, who know lime and how to manufacture it—services that have been tried and found not wanting. This is evidenced by the work we have in hand, among which is a 50 ton plant for the Abel Magnesia Co., Cedarville, O.; 80 ton plant, John Evans Lime and Stone Co., Marion, O.; 40 ton plant, Ste. Genevieve Lime and Stone Co., Ste. Genevieve, Mo.; and a 40 ton plant for the Consolidated Stone and Mining Co., Newcastle, Pa.



We maintain a testing laboratory and are therefore in a position to give you accurate information as to whether or not your stone will burn properly and make a good hydrate. Moreover, for just what purposes the hydrate is suited for. This service costs you nothing. Send us a 100 lb. sample of your stone and we will make these tests for you. The opinion of experts is at your disposal.

Economy, efficiency and service satisfaction has accompanied every **Clyde Hydrator** that we have installed. Fully 90 per cent of the hydrate manufactured in America is produced with the Clyde. It proves that the Clyde is a Superior Hydrator for no article ever attained such preponderance in its favor without manifest superiorities. It is the machine built for performance.

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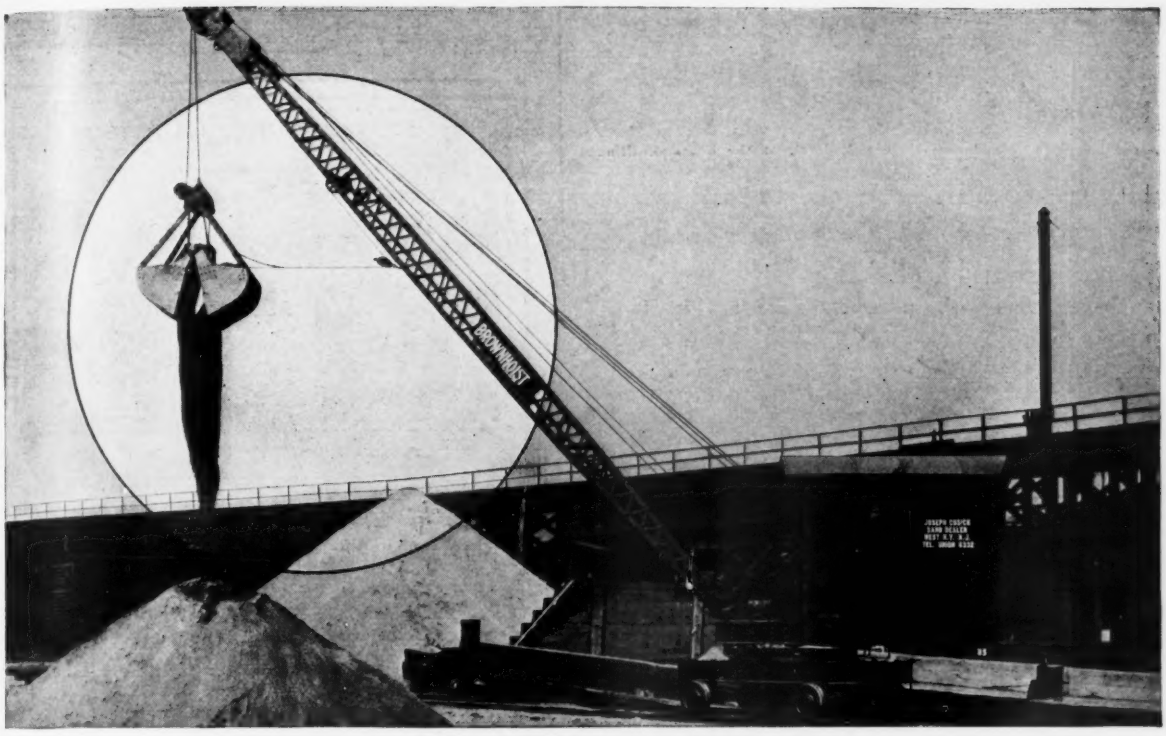
H. MISCAMPBELL

DULUTH **MINNESOTA**



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MOBILITY

Putting greater power in the thrust—

THE outstanding success of the Northwest in stone quarries is explained by a number of advanced features.

Foremost among these is the simple arrangement of cables which eliminates gears, racks, pinions, auxiliary motors and auxiliary drives. With this arrangement there is positively no reduction of digging power while hoisting—an advantage not shared by other shovels. There is nothing to wear out but the long lived cables.

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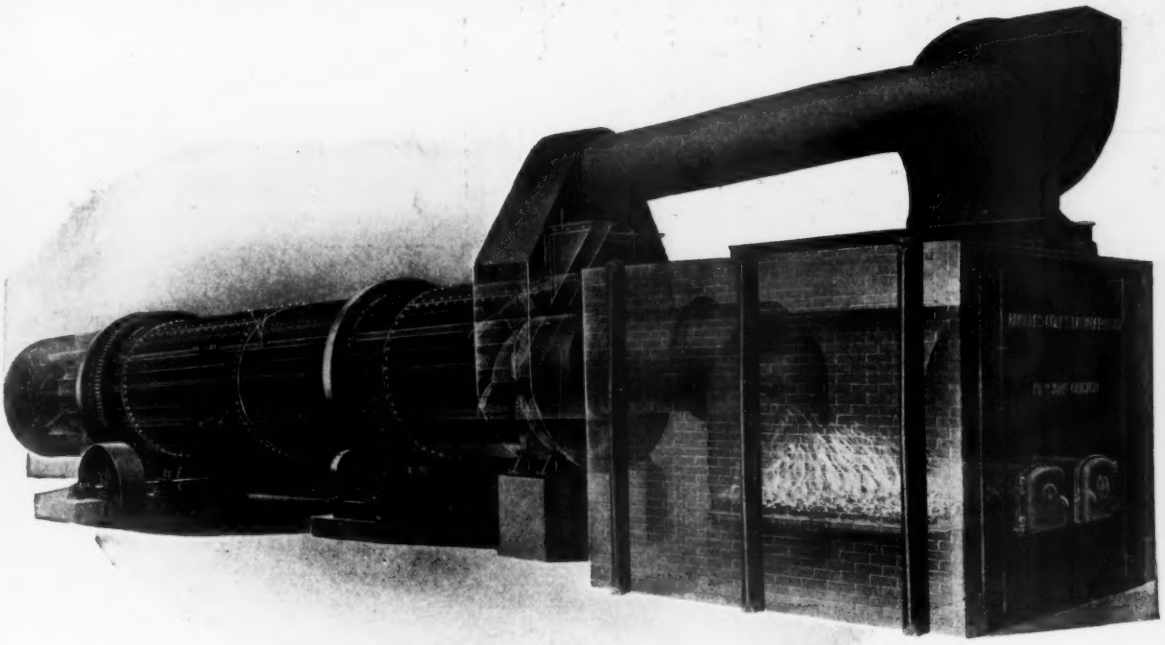

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Do you realize that grinding efficiency is increased approximately 10 per cent for each additional 1 per cent of moisture removed from ordinary classes of materials fed to pulverizers? This condition maintains until a state of absolute dryness is reached.

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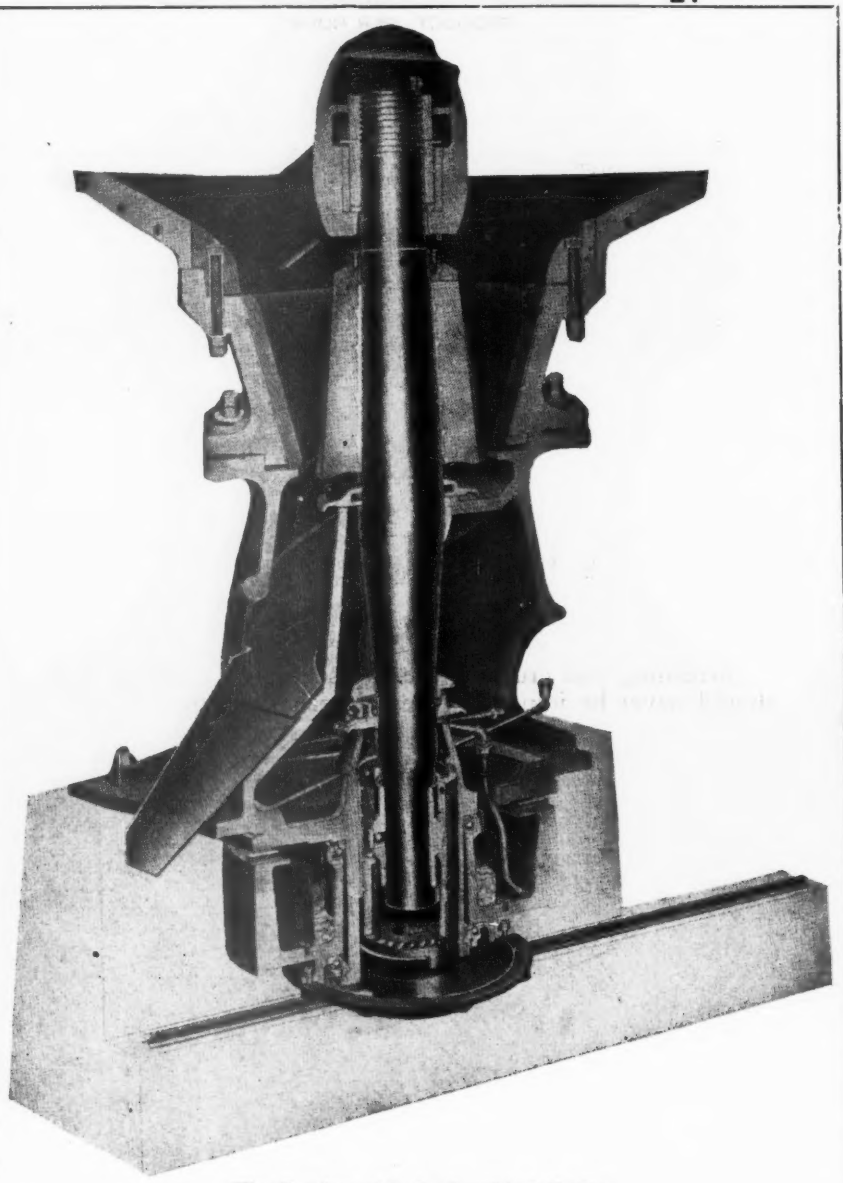

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Points of Superiority

1. Less Power Consumption
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3. Continual Operation —Not Limited to Safe Gear Speed— Strikes a Harder Blow, and Has Increased Capacity
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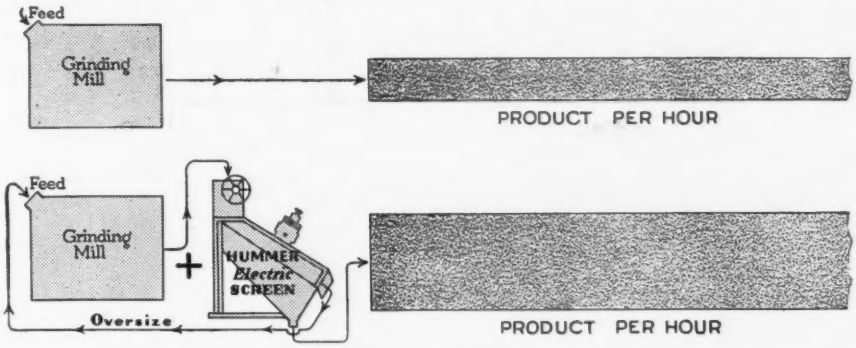

Make one mill do the work of two!

with the same power
with the same up-keep

Type 31
6-Foot, Two Surface
HUM-MER *Electric* Screen

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And this with the same power and up-keep.

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Let us show you how to reap profits by installing HUM-MER Electric Screens. Send for Catalogue 45-R

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"HEAVY DUTY"

SINGLE LEVER STEERING

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Elevate or lower or swing boom under load. KOEHRING construction permits this combination of functions with no penalty of extra wear or strain.

No. 2 Capacity: 12 tons at 12′ radius. ½ yard clamshell bucket loaded with sand or gravel at 45′ radius. ¾ yard clamshell bucket loaded with sand or gravel at 39′ radius. 1 yard clamshell bucket loaded with sand or gravel at 33′ radius. 1½ yard clamshell bucket loaded with sand or gravel at 24′ radius. 1 yard Page drag bucket on a 40′ boom.

No. 3 Capacity: 20 tons at 12′ radius. 1 yard clamshell bucket loaded with sand or gravel at 50′ radius. 1½ yard clamshell bucket loaded with sand or gravel at 39′ radius. 2 yard clamshell bucket loaded with sand or gravel at 33′ radius. 1½ yard Page drag bucket at 40′ radius.

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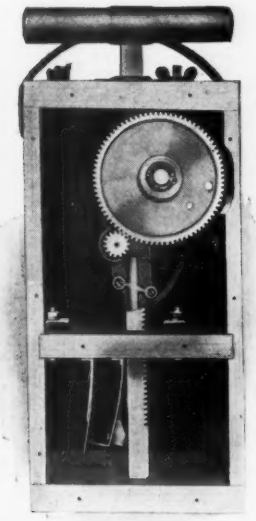
KOEHRING COMPANY

Manufacturers of Concrete Mixers and Crane Excavators

Milwaukee, Wisconsin

This shows the new greatly improved Hercules Blasting Machine.



The inside workings of the Hercules Blasting Machine.

An Improved Blasting Machine

The new Hercules Blasting Machine was developed during the war after the United States Army Ordnance Department found that the machines formerly used did not meet the severe and exacting requirements of military service. This improved machine is more reliable and, in extensive use, has already proved its superiority over the types formerly used for industrial work.

In the old model, much of the energy of the operator is consumed uselessly in the machine itself, and the small current that enters the cap circuit is of very short duration. In our new machine, the blasting circuit is closed at the instant of maximum voltage and amperage, and the current is maintained in the circuit for an appreciable period. Besides delivering a greater current at a higher voltage, the new Hercules machine sustains this current longer.

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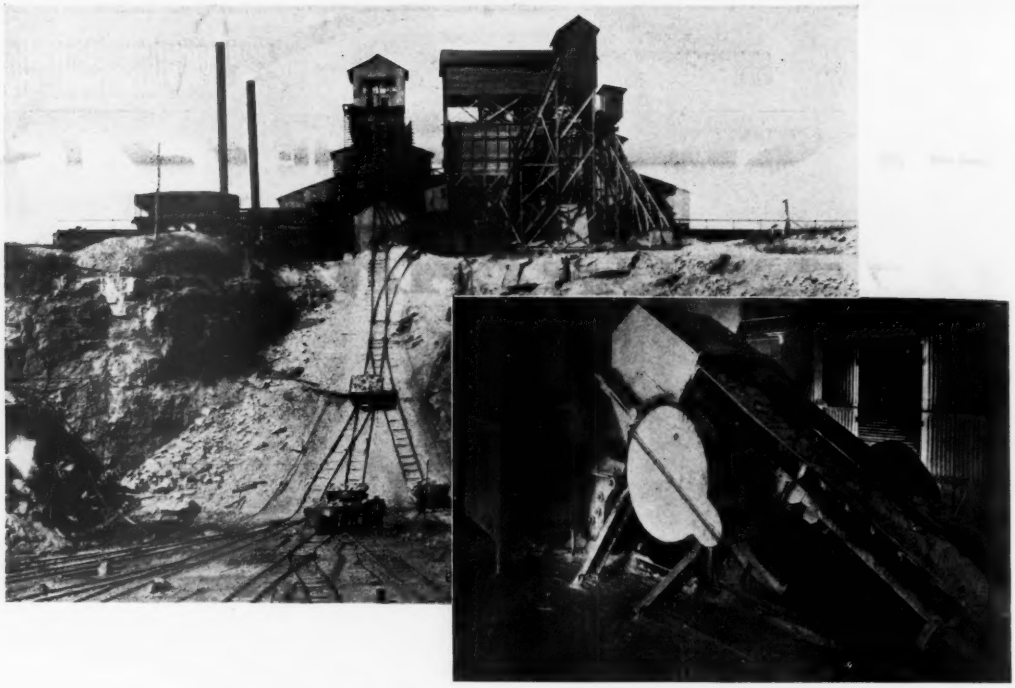

"Doing More Work Than Anticipated at Very Low Operating Cost"

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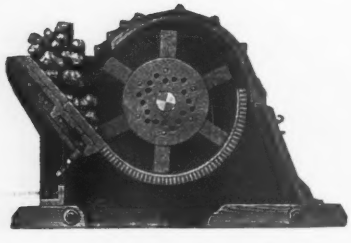

"Have not tried a machine that gave us better results."—Dittlinger Lime Co., New Braunsfels, Texas.

"Crushing 1925 pounds per minute of 8-in. lime to dust—establishing a remarkable record."—Luckey Lime & Supply Co., Luckey, Ohio.

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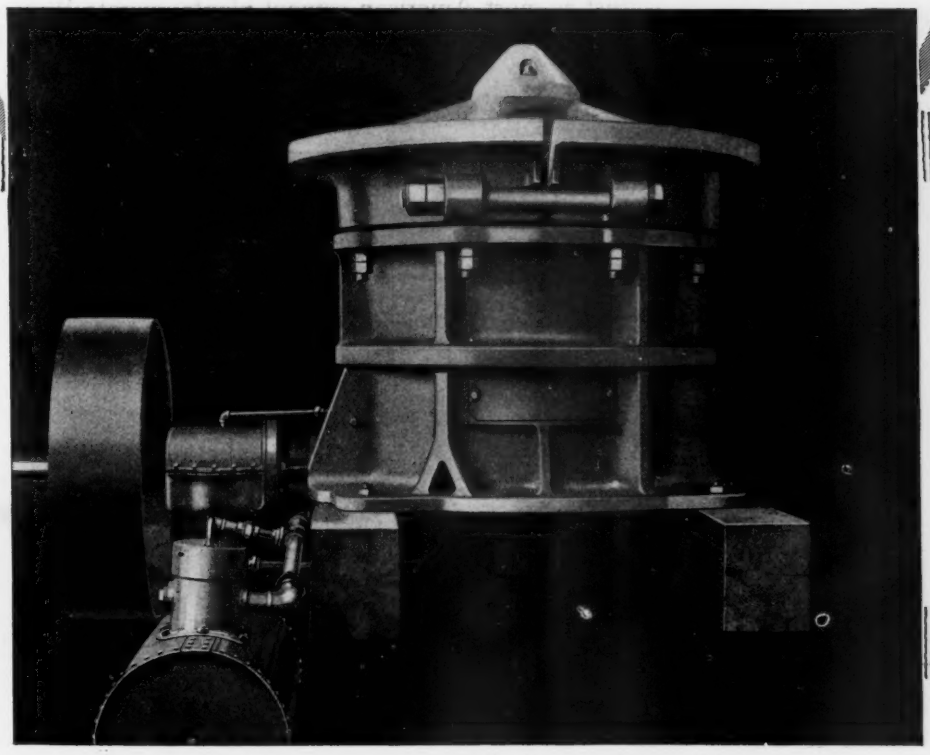

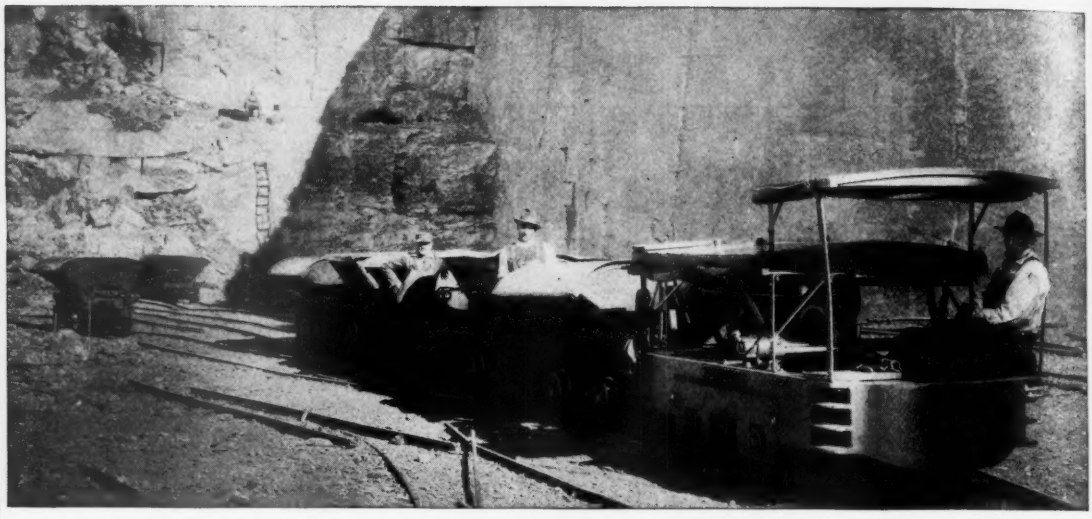

The American Lime & Stone Co.
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The American Lime and Stone Company (Warner-American Industries) are one of the really big lime and stone industries of the country.

They have six Plymouth Locomotives at their various plants, and the company writes of their good work, stressing their reliability, the volume of production they are able to handle, simplicity of operation and remarkably low upkeep.

If you contemplate a change in your haulage methods, name the nature of your plant and we will supply you with appropriate literature.

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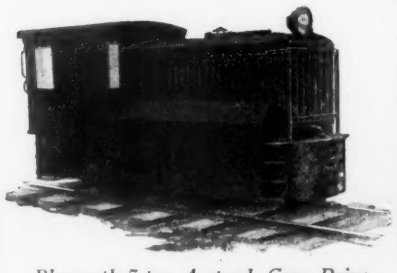

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